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Yoshida et al.

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(54) **BATTERY AND ELECTRONIC DEVICE**

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(22) Filed: **Jun. 27, 2018**

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Related U.S. Application Data

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(30) **Foreign Application Priority Data**

Dec. 28, 2015 (JP) 2015-255668

(51) **Int. Cl.**

H01M 2/36 (2006.01)

H01M 6/32 (2006.01)

A61B 5/00 (2006.01)

(52) **U.S. Cl.**

CPC **H01M 2/365** (2013.01); **A61B 5/6861** (2013.01); **H01M 2/36** (2013.01); **H01M 2/368** (2013.01); **H01M 6/32** (2013.01)

(58) **Field of Classification Search**

CPC H01M 2/36; H01M 2/365; H01M 2/368; H01M 6/32; A61B 5/6861

See application file for complete search history.

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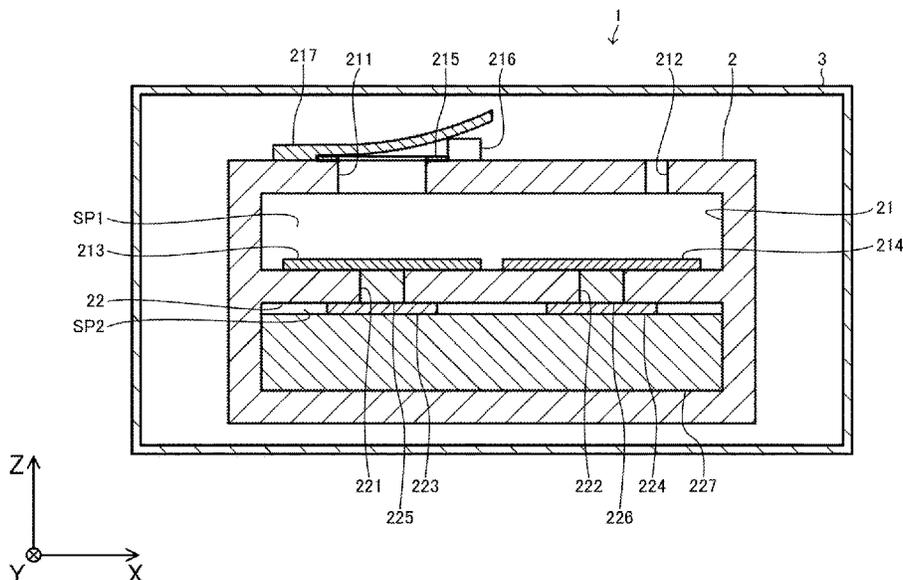
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(57) **ABSTRACT**

A battery includes a main body having a space therein, and including a channel communicating between an outside and the space; a pair of electrodes adjoining the space; and a valve that closes the channel responsive to pH.

11 Claims, 36 Drawing Sheets



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FIG. 1

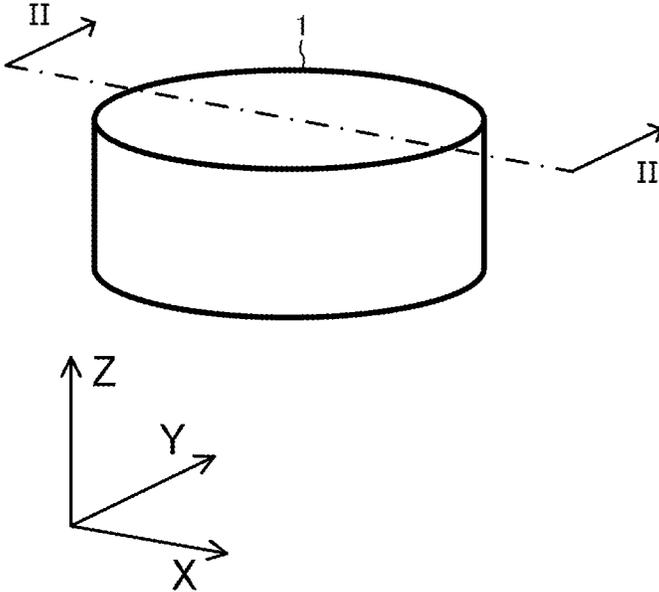


FIG. 2

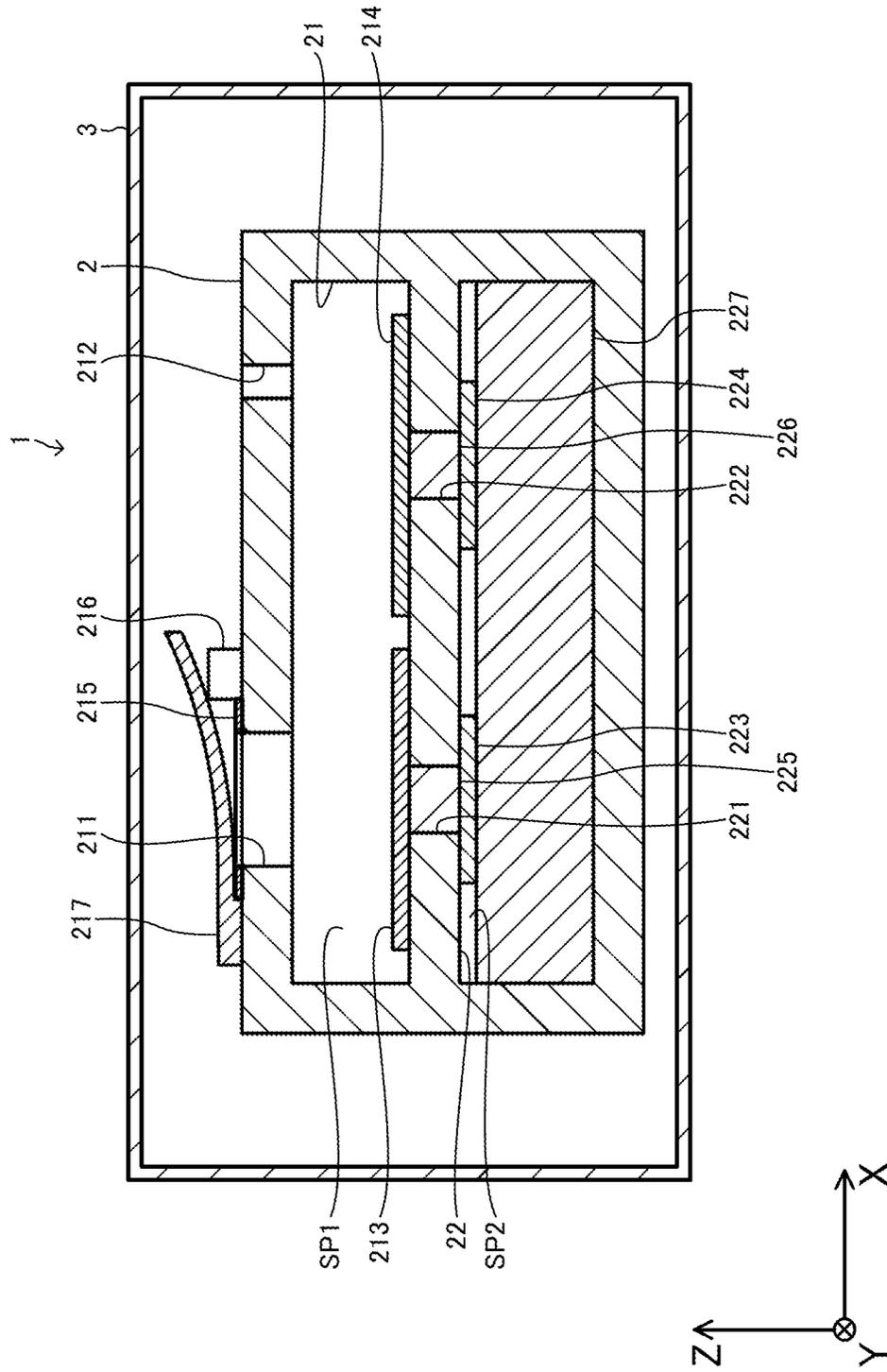


FIG. 3

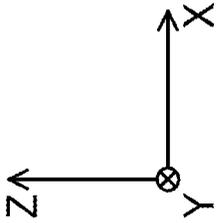
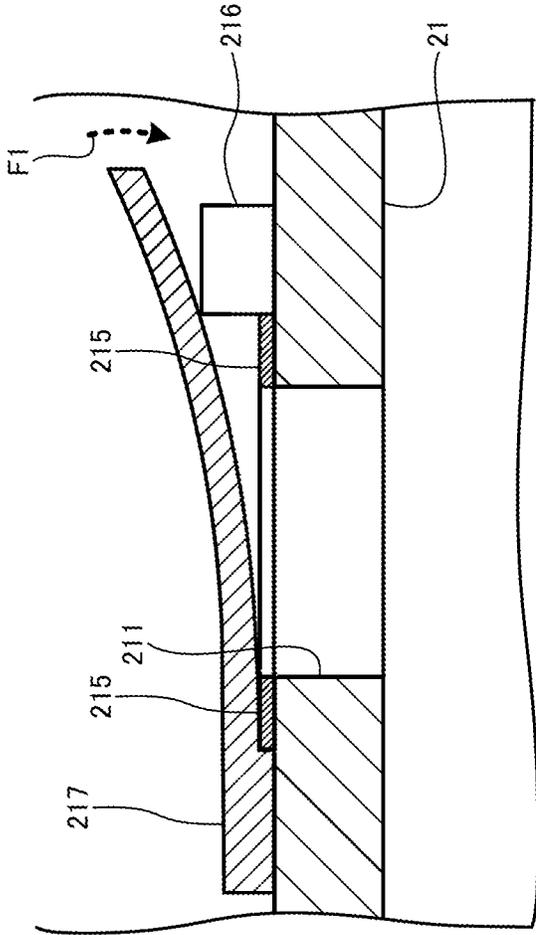


FIG. 4

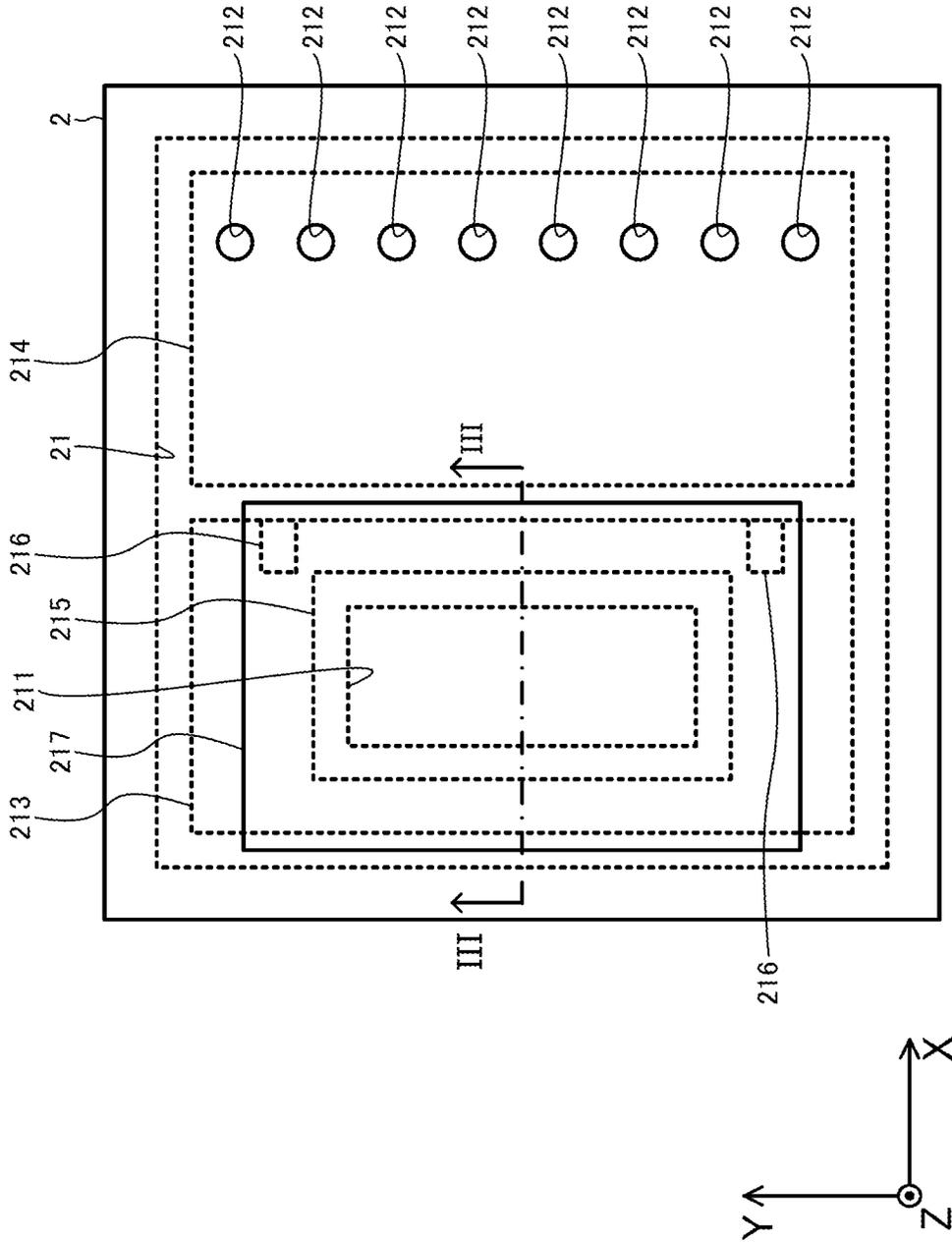


FIG. 5

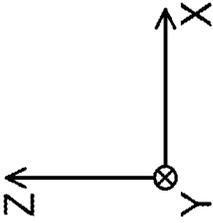
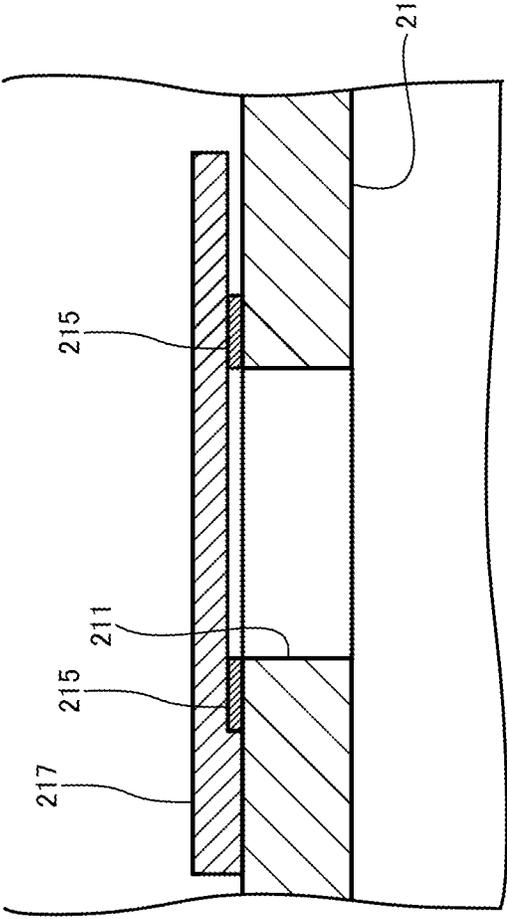


FIG. 6

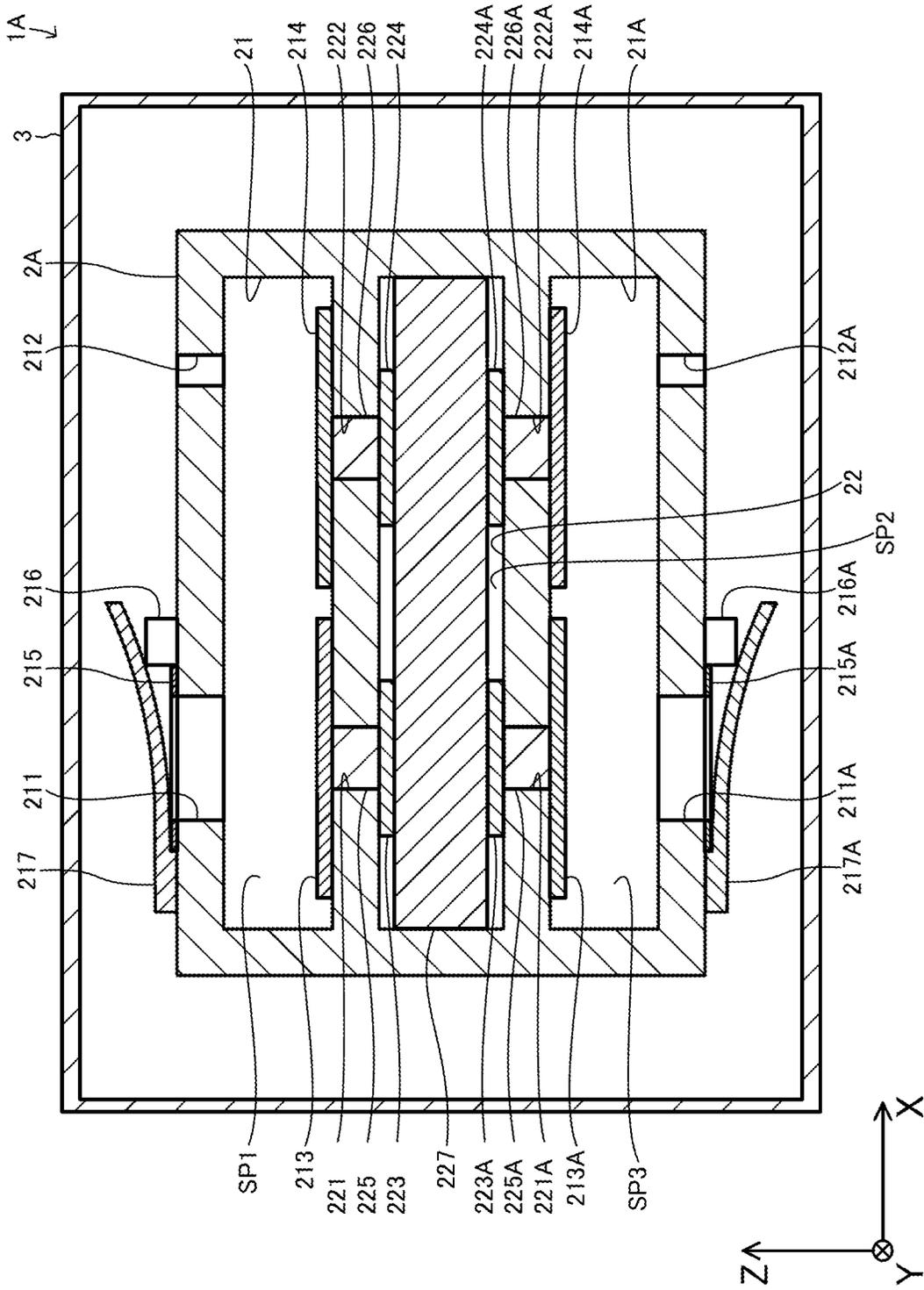


FIG. 7

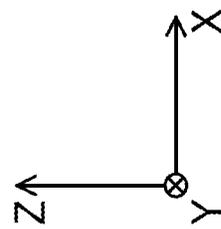
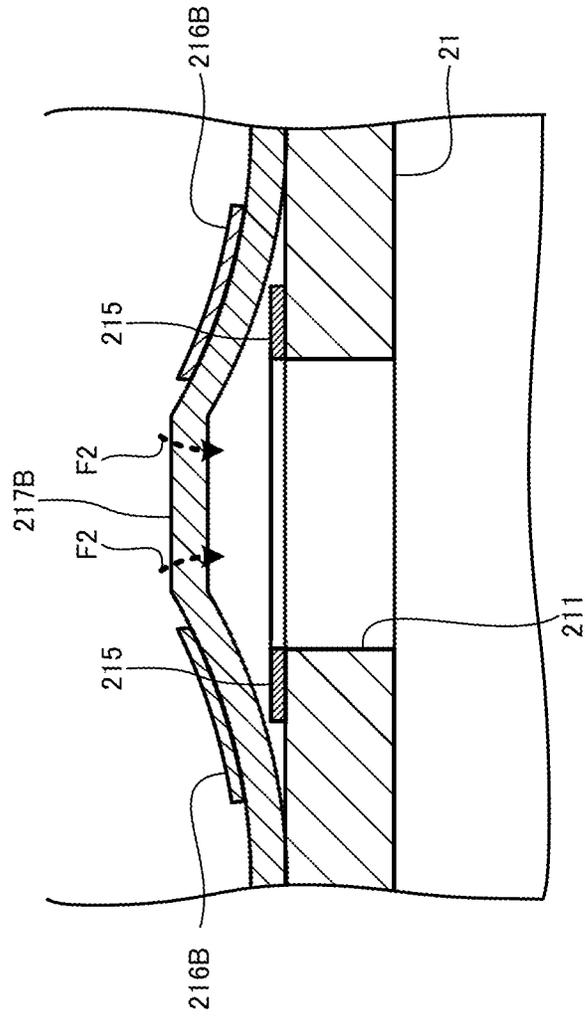


FIG. 8

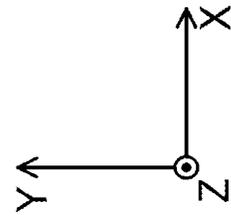
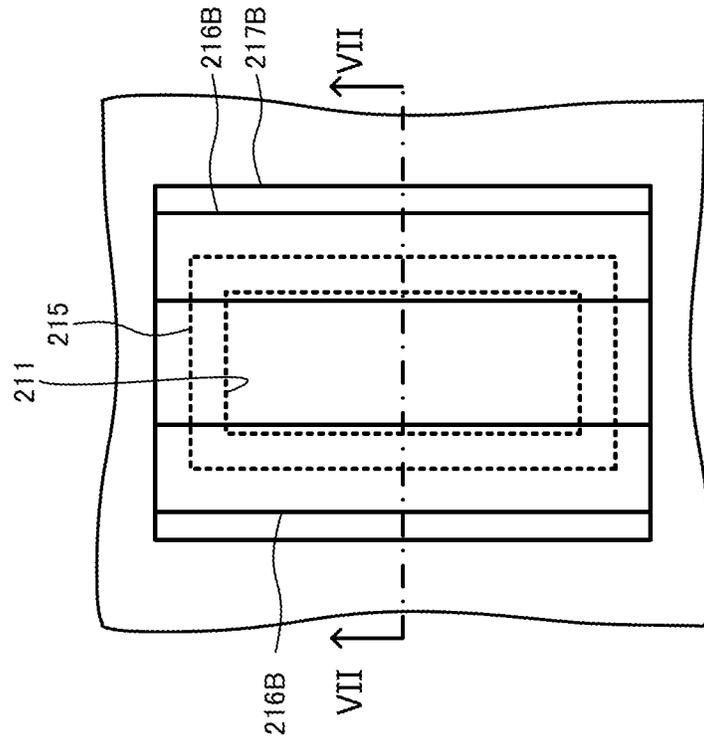


FIG. 9

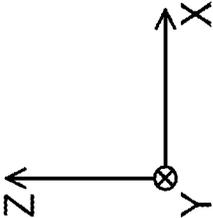
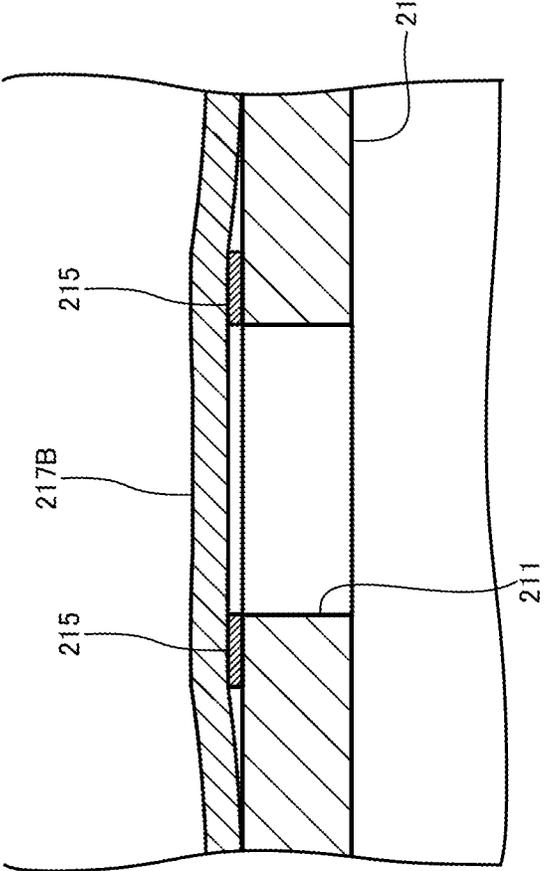


FIG. 10

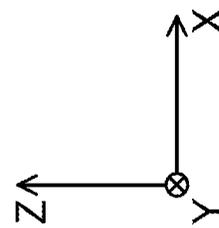
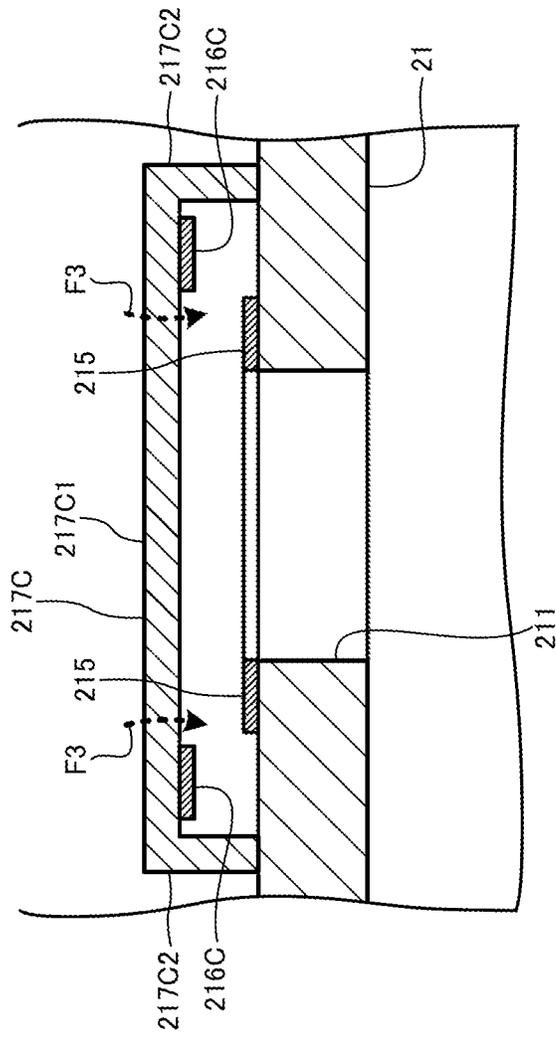


FIG. 11

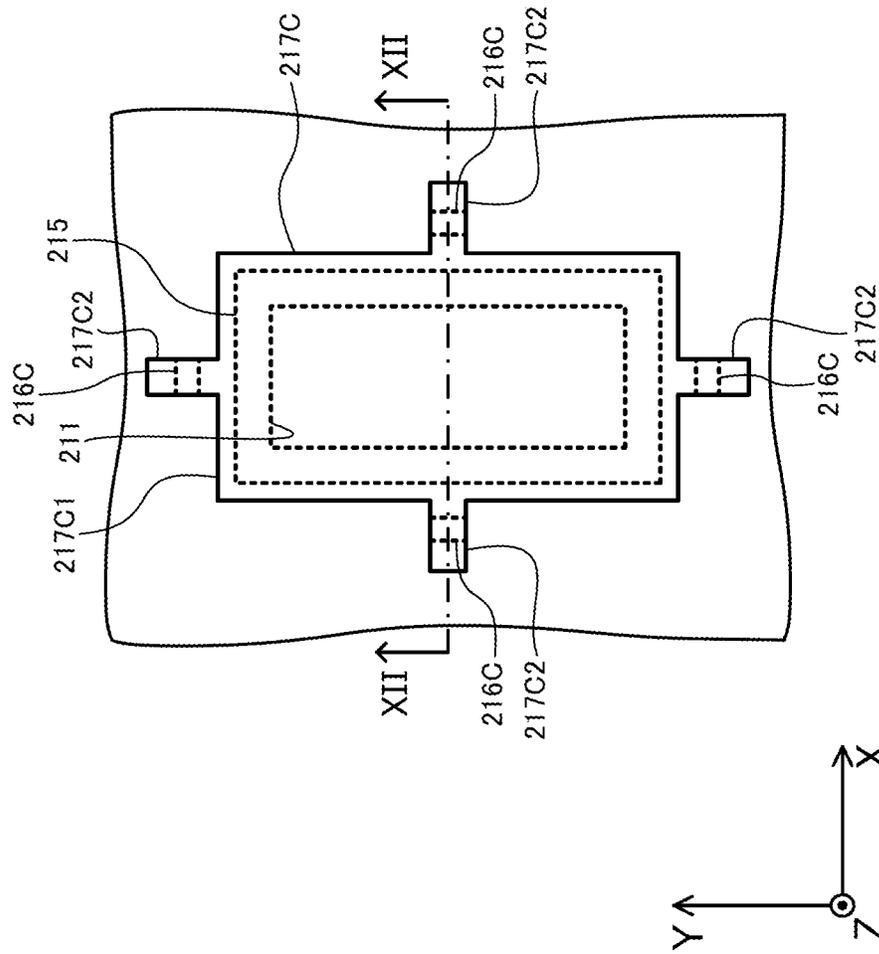


FIG. 12

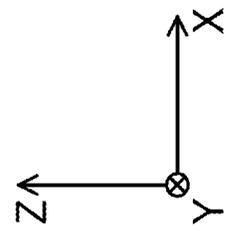
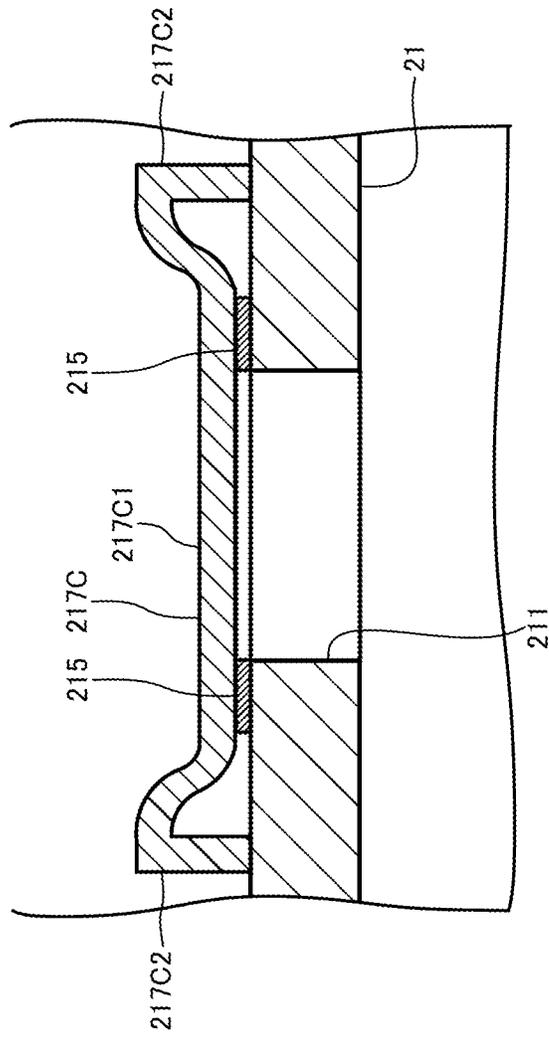


FIG. 13

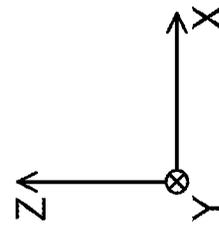
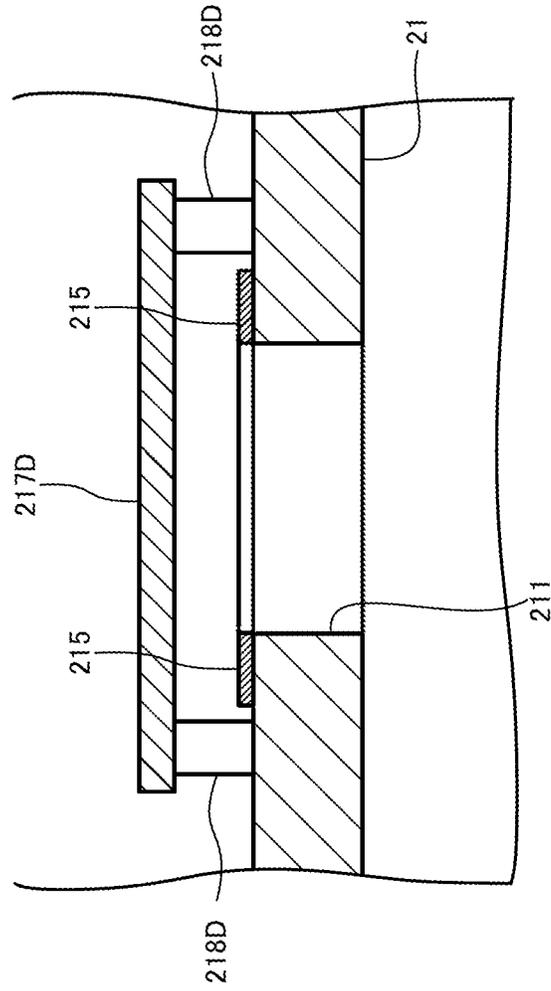


FIG. 14

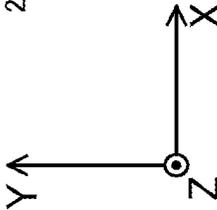
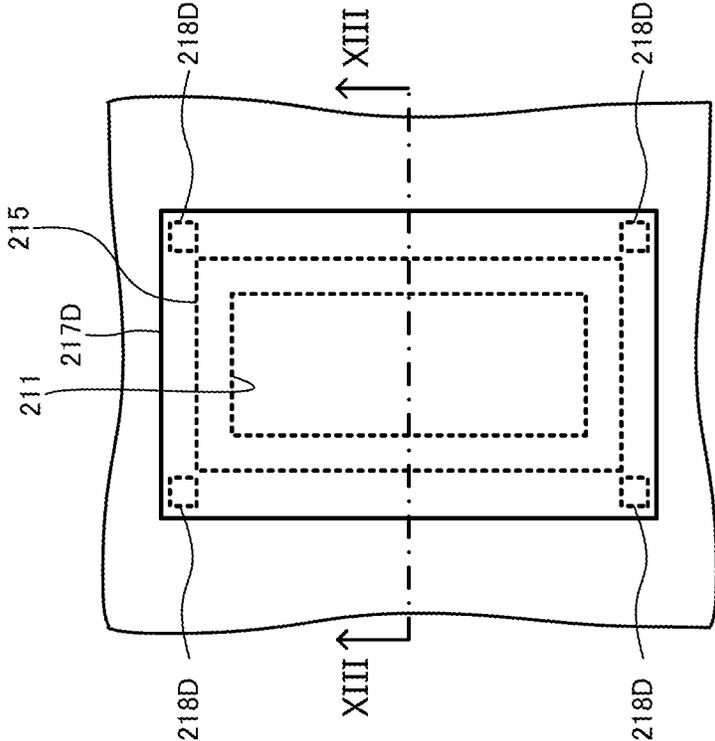


FIG. 15

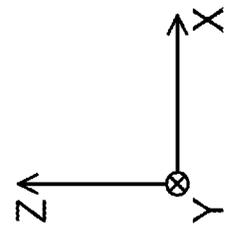
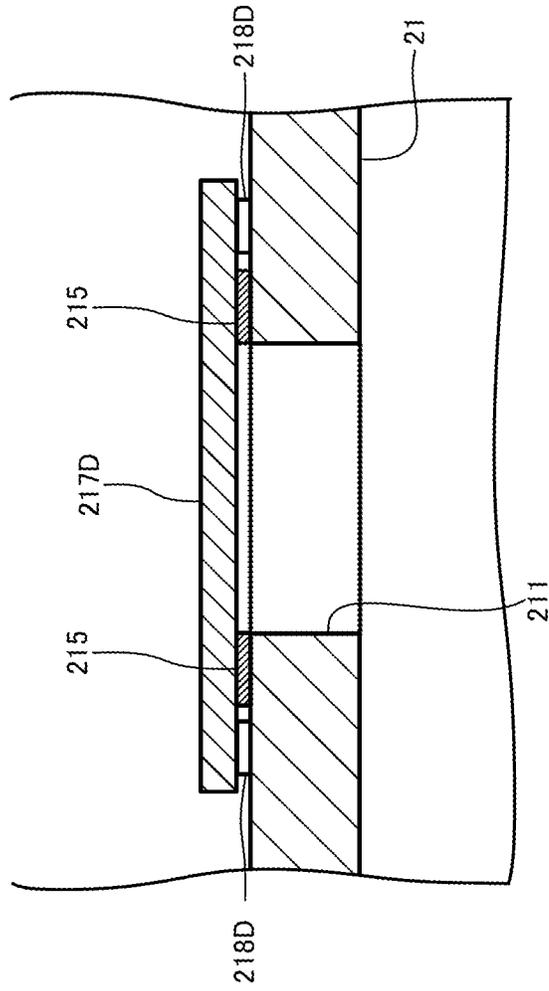


FIG. 17

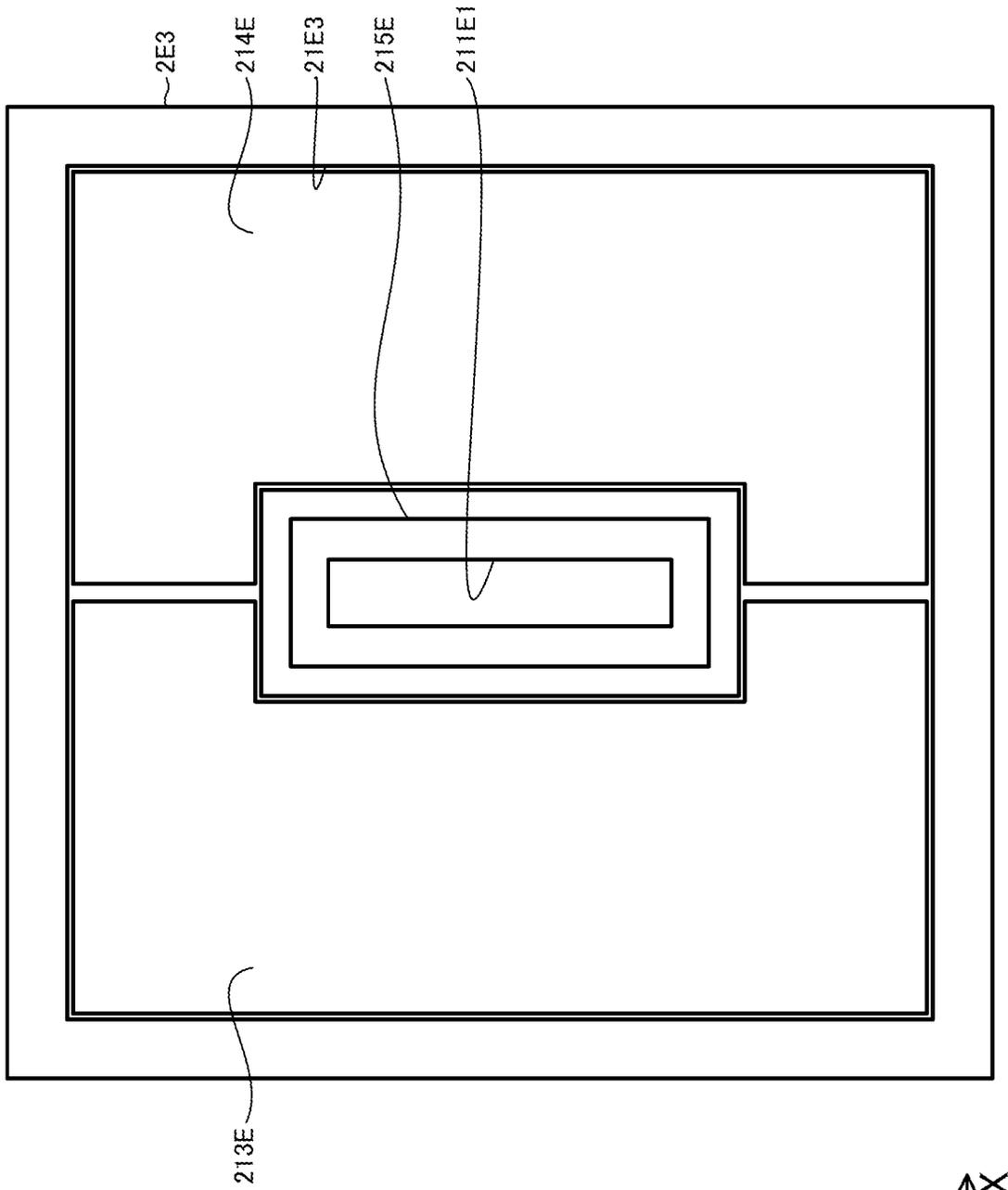


FIG. 18

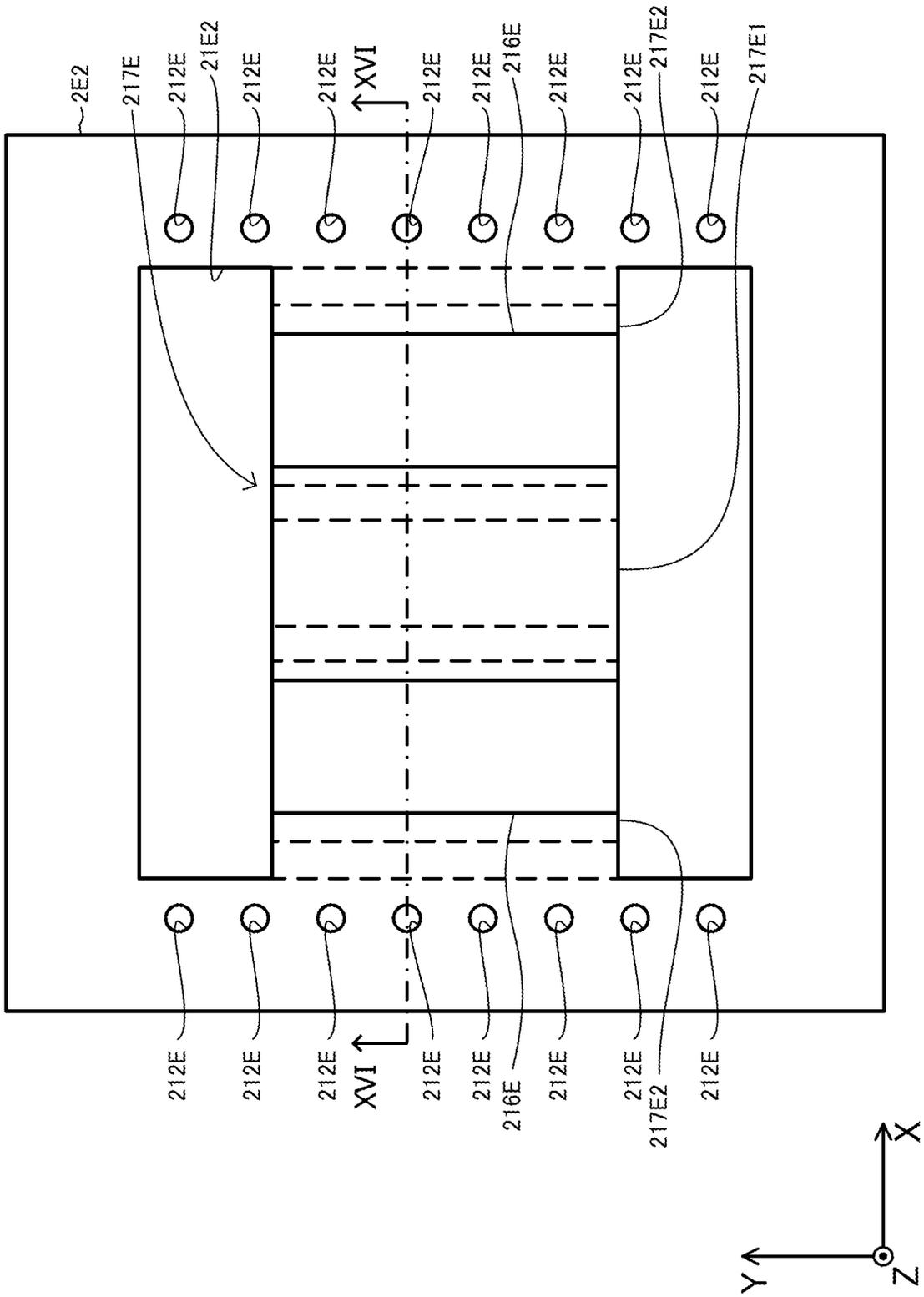


FIG. 19

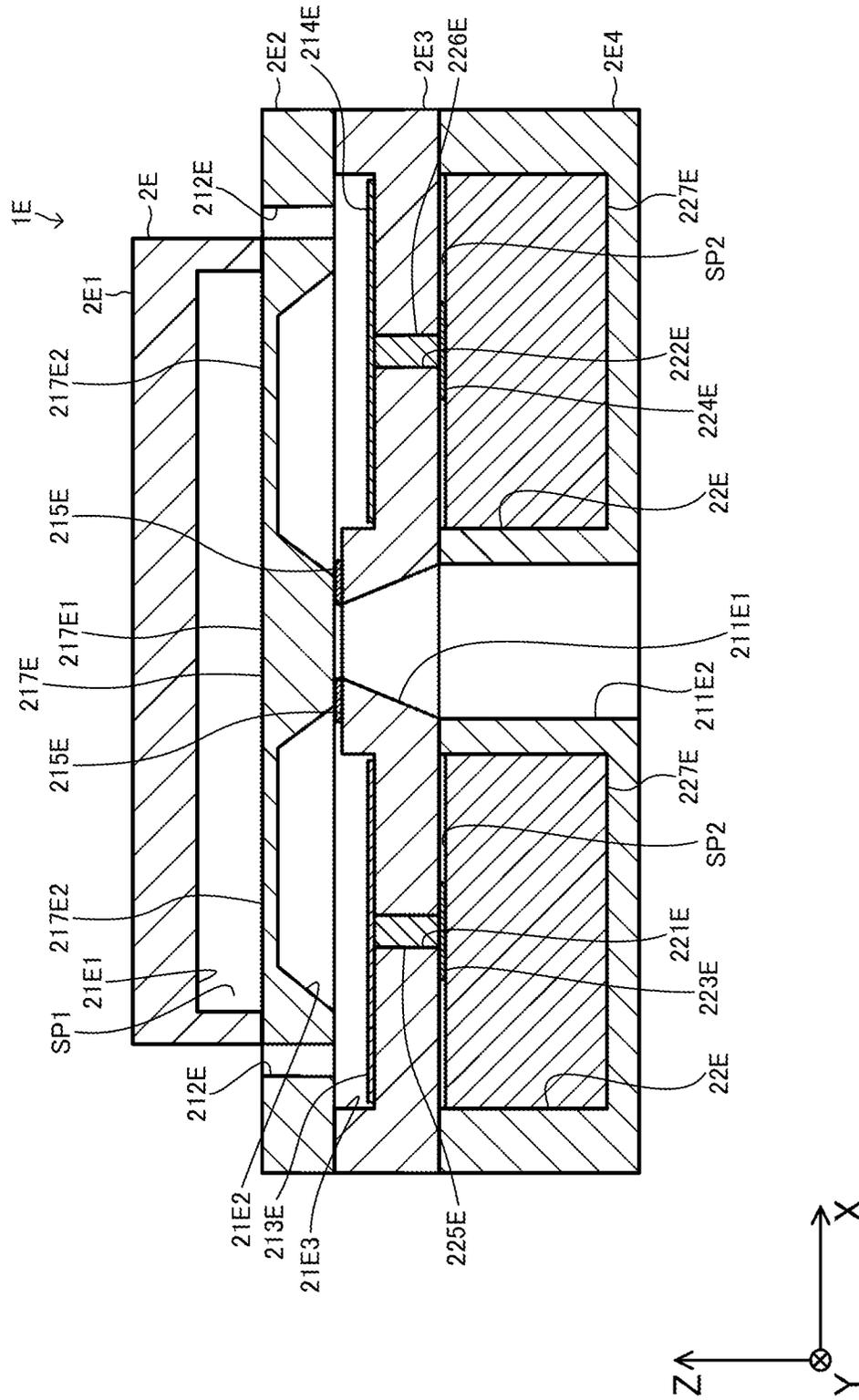


FIG. 20

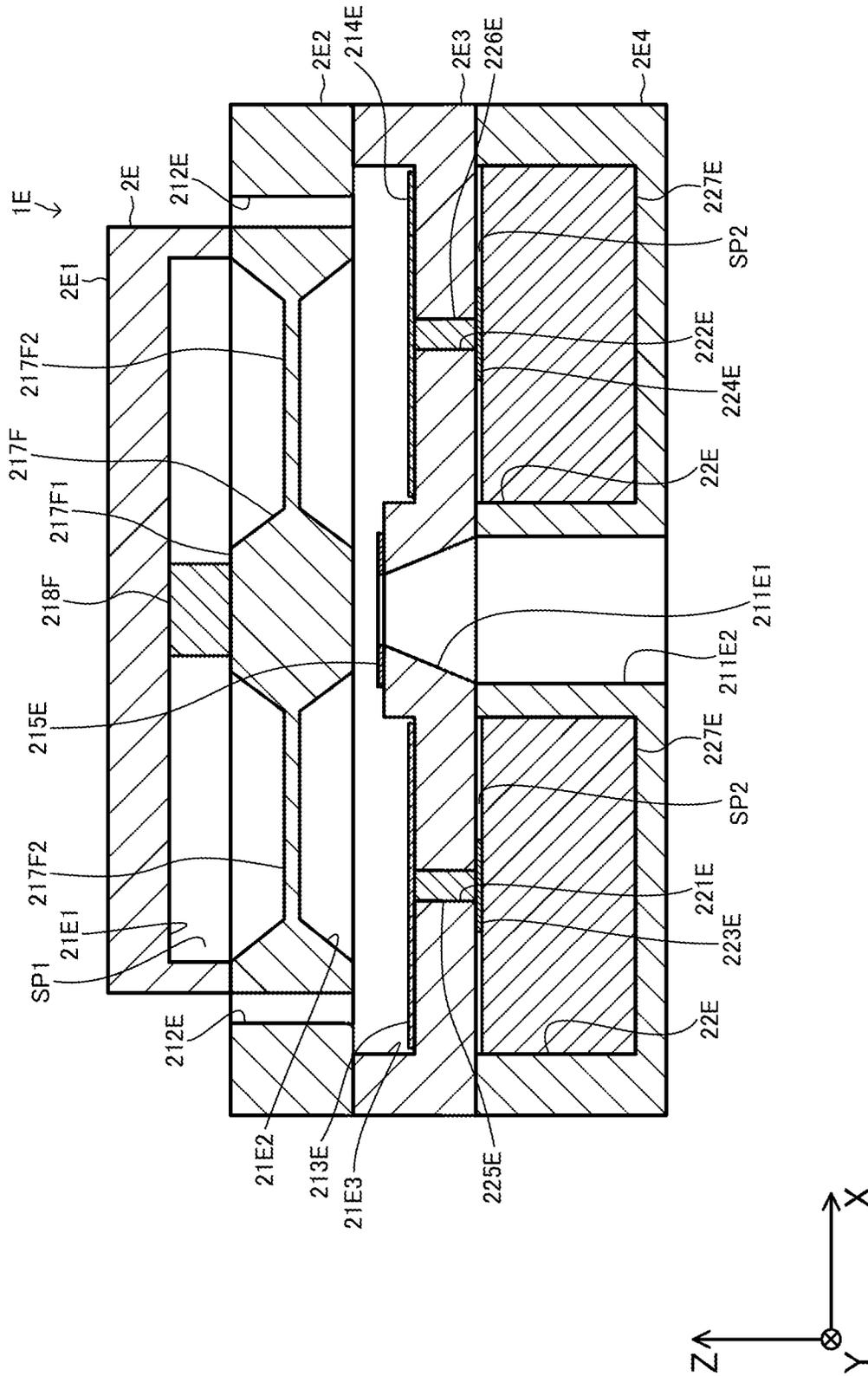


FIG. 22

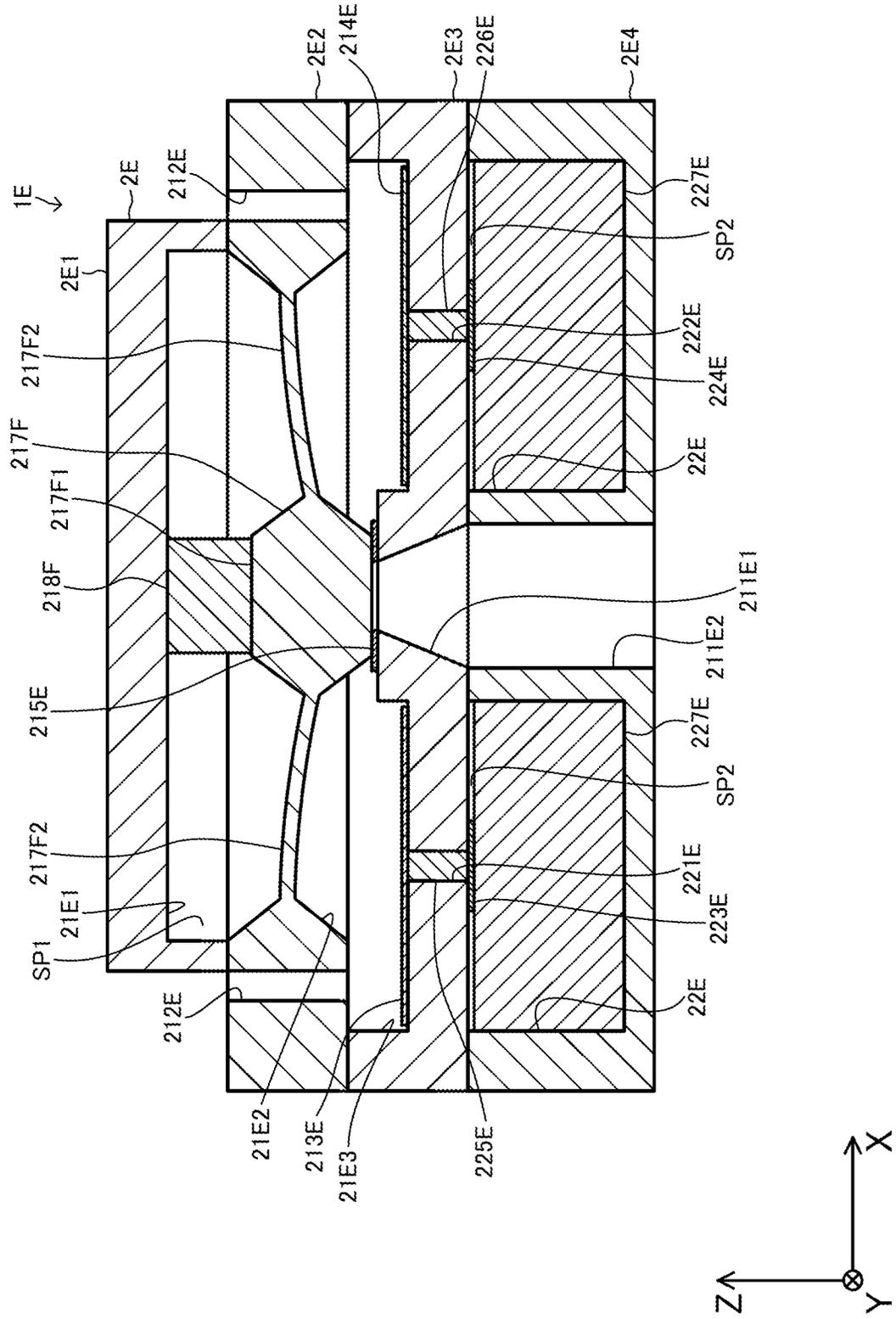


FIG. 24

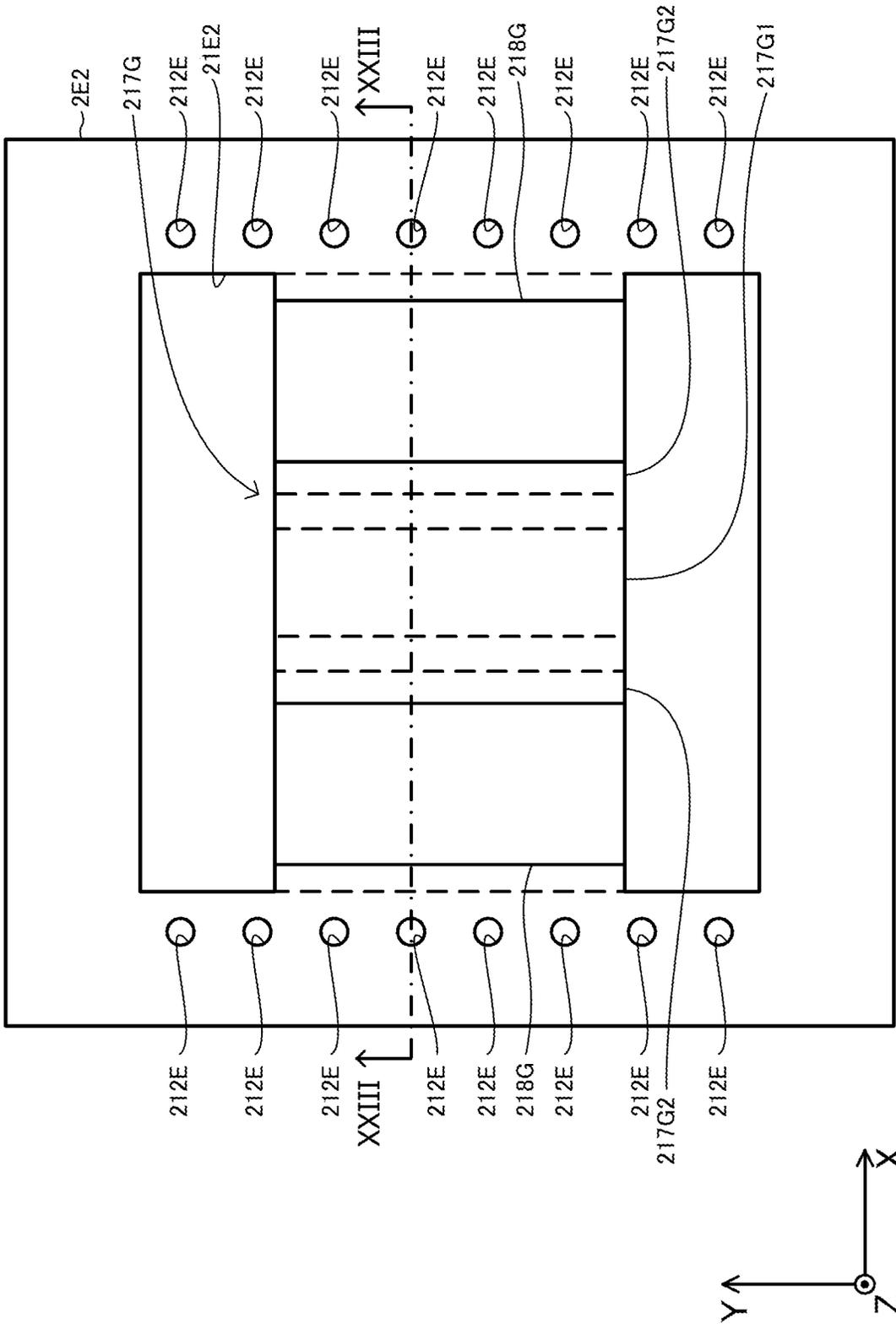


FIG. 25

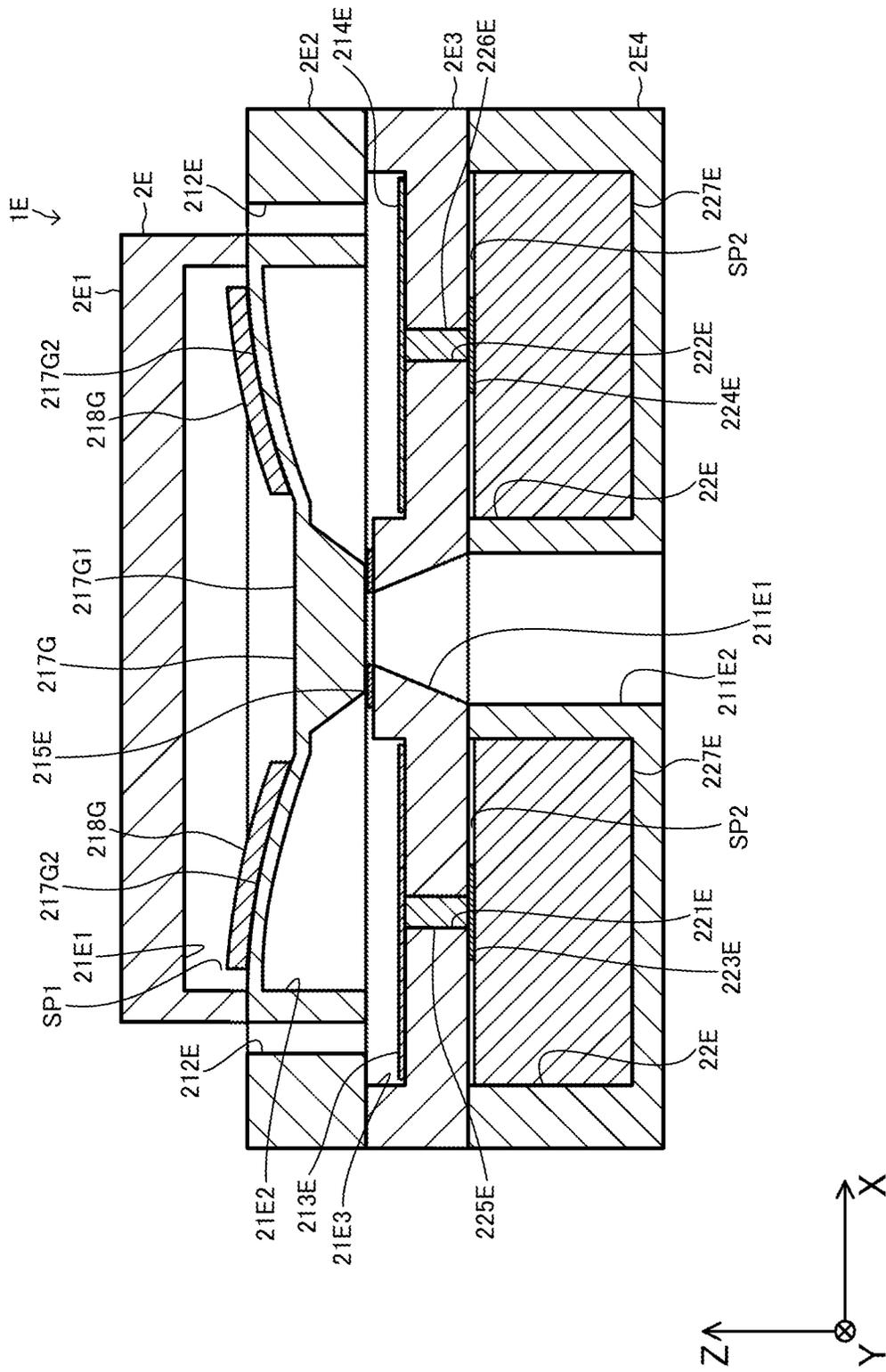


FIG. 26

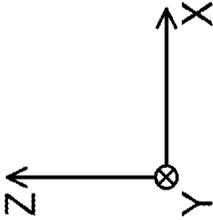
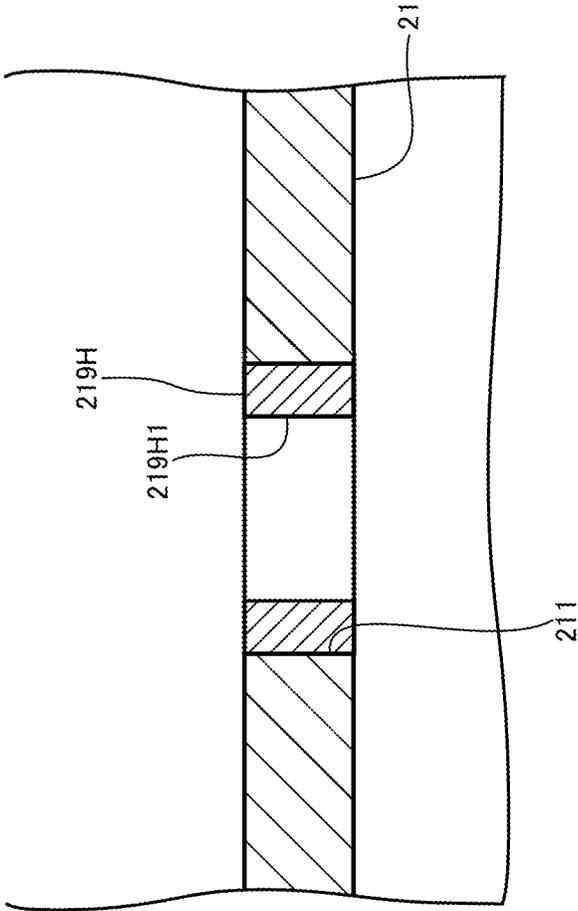


FIG. 27

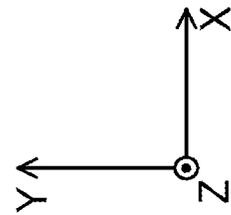
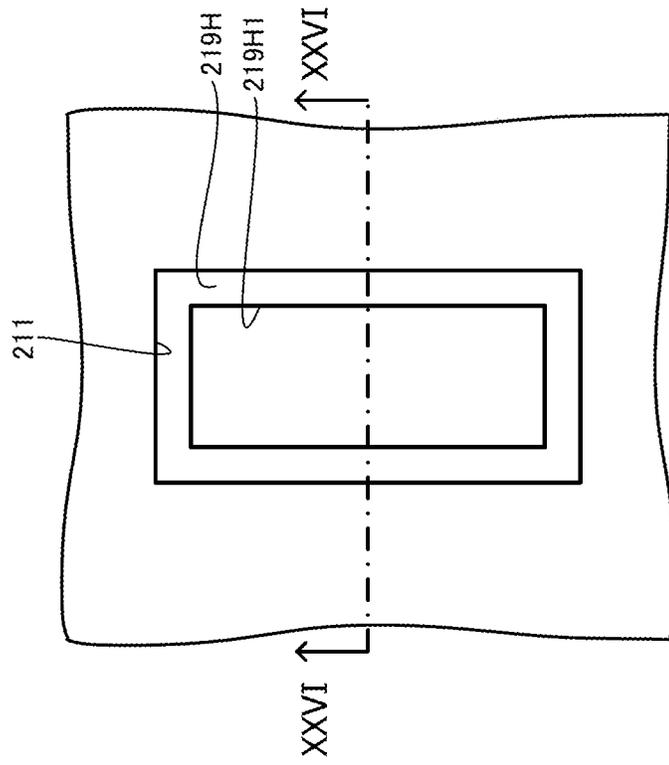


FIG. 28

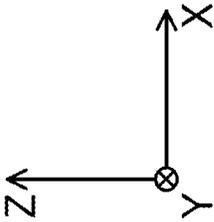
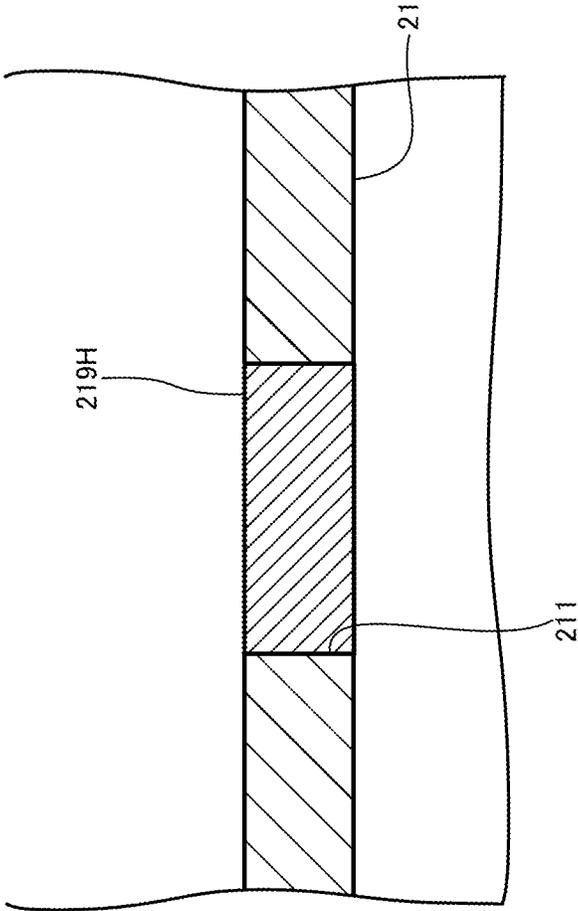


FIG. 29

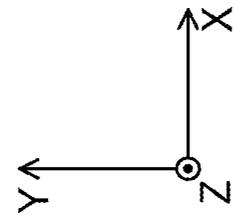
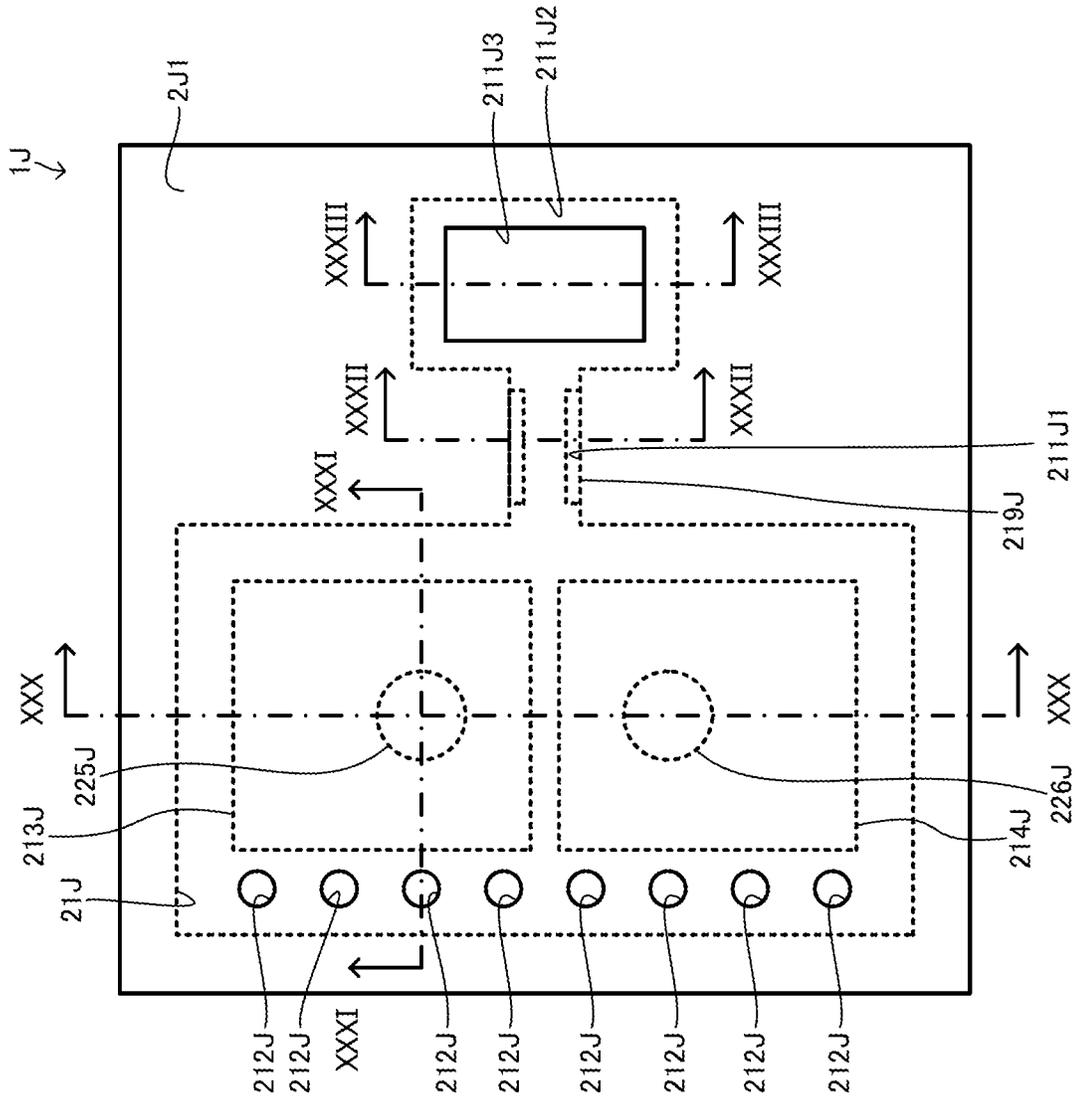


FIG. 30

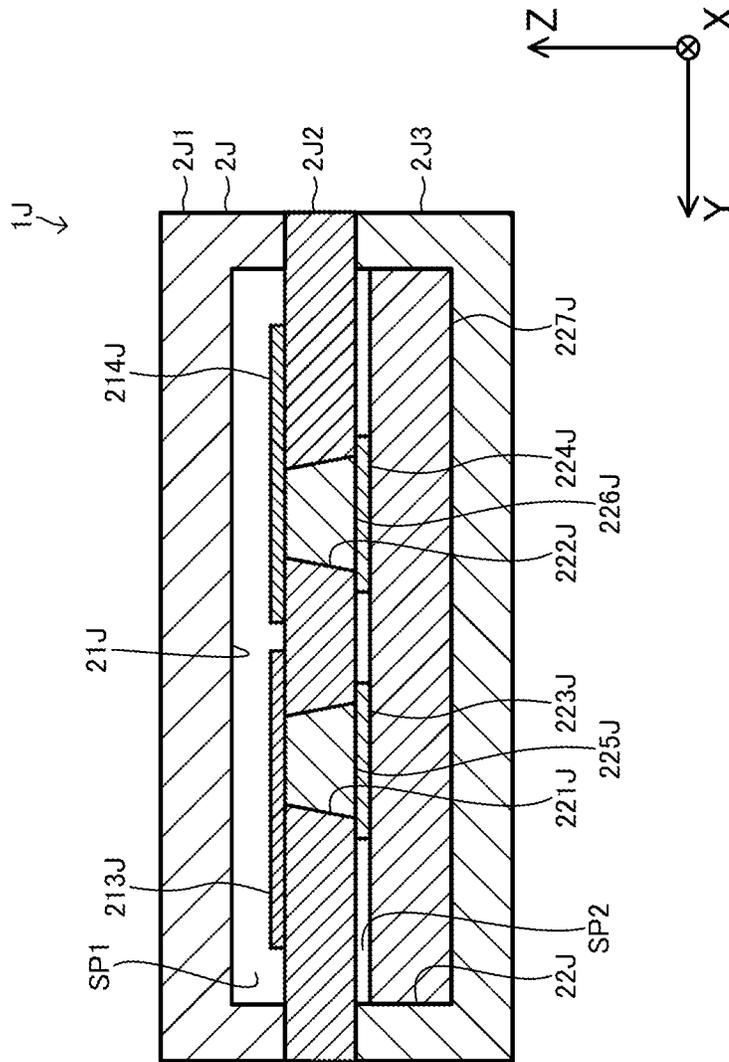


FIG. 31

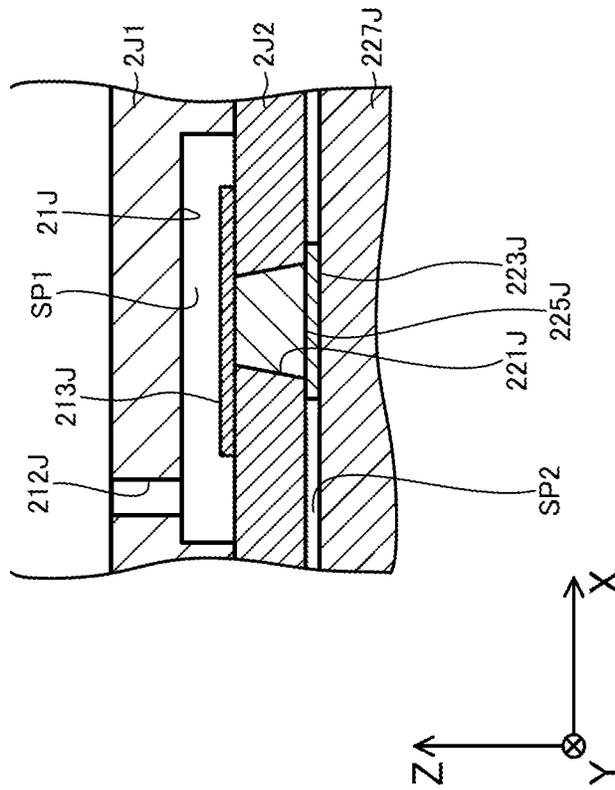


FIG. 32

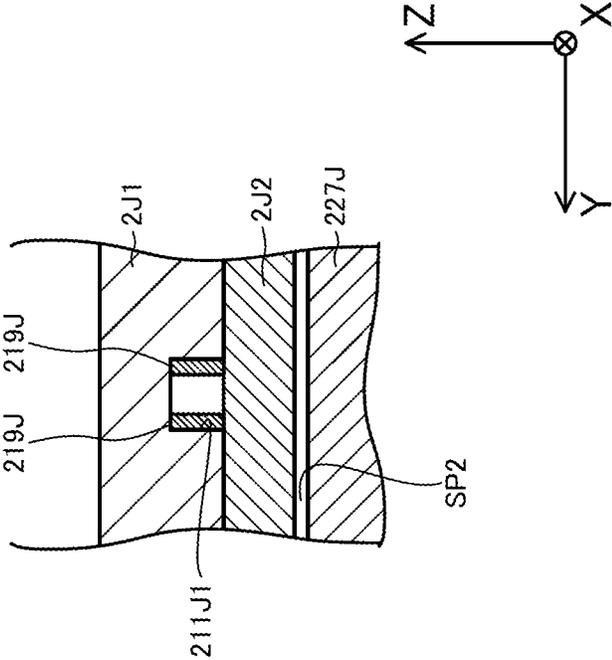


FIG. 33

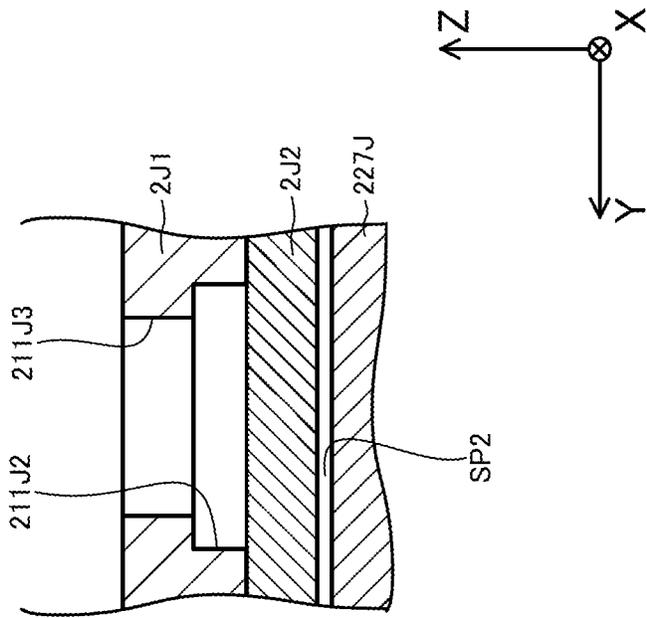


FIG. 34

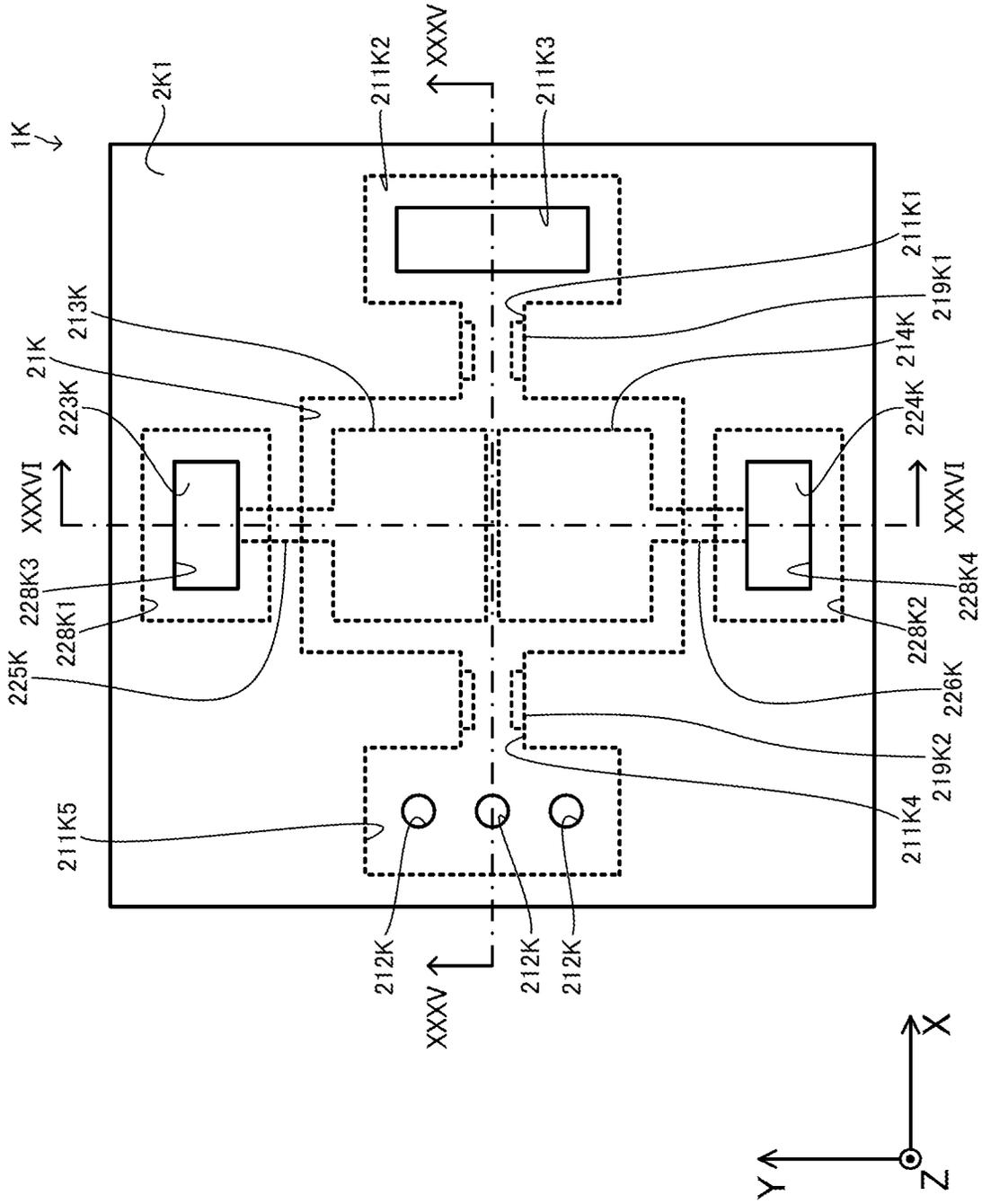


FIG. 35

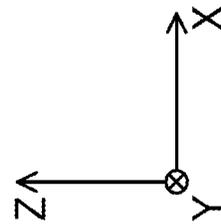
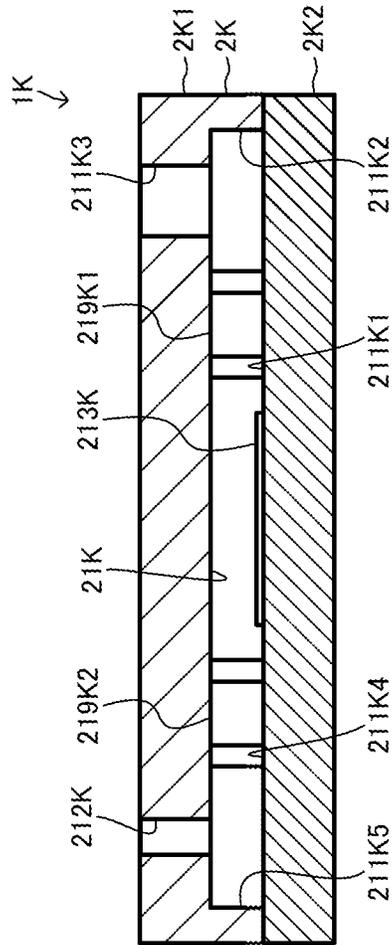
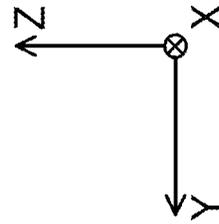
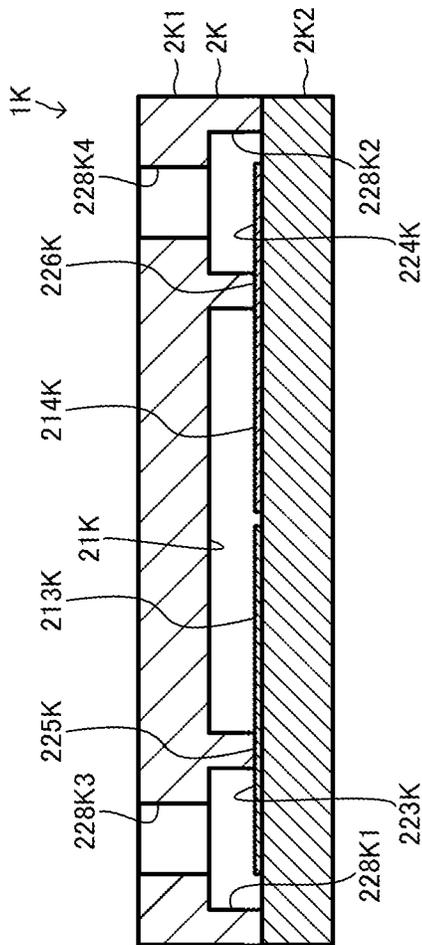


FIG. 36



1

BATTERY AND ELECTRONIC DEVICE**CROSS-REFERENCE TO RELATED APPLICATION**

This application is a continuation application of International Application PCT/JP2016/057496, filed on Mar. 10, 2016 and designated the U.S., which claims priority to Japanese Patent Application No. 2015-255668, filed on Dec. 28, 2015. The contents of these applications are incorporated herein by reference.

FIELD

The embodiments discussed herein are related to a battery and an electronic device.

BACKGROUND

Batteries are known, which are introduced to the digestive tract of a living body where a fluid in the digestive tract functions as an electrolyte, to generate electric power. For example, the battery disclosed in Patent Document 1 includes a space to which a fluid is to enter, and a channel communicating between the space and the outside of the battery. The gastric fluid are used as a fluid acting as an electrolyte.

LIST OF RELATED ART DOCUMENT

[Patent Document 1] Japanese Laid-open Patent Publication No. 2010-508293

In the meantime, matters other than gastric fluid, such as fluids with a higher pH than that of the gastric fluid (e.g., pancreatic fluid, bile, and intestinal fluids) and solid matters (e.g., foods and feces), are present in the digestive tract downstream to the stomach.

Thus, in the digestive tract downstream to the stomach, such matters other than the gastric fluid may accidentally enter the space inside the battery. For example, if a fluid with a higher pH than that of the gastric fluid enters the space inside the battery, the pH of the fluid in the space may exceed that of the gastric fluid. Or, a solid matter may enter the space inside the battery, and the solid matter may attach to an electrode, for example. There have been issues where the entry or adhesion sometimes leads to a reduction in the output of electric power (in other words, the power output) generated by the battery in the digestive tract downstream to the stomach.

Such issues may also arise when a fluid other than gastric fluid is used as an electrolyte-acting fluid.

SUMMARY

In one aspect, a battery includes: a main body having a space therein, and having a channel communicating between an outside and the space; a pair of electrodes adjoining the space; and a valve that closes the channel responsive to pH.

In another aspect, an electronic device includes: a battery that generates electric power; and a circuit that is energized by the generated electric power, the battery including: a main body having a space therein, and having a channel communicating between an outside and the space; a pair of electrodes adjoining the space; and a valve that closes the channel responsive to pH.

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The object and advantages of the invention will be realized and attained by means of the elements and combinations particularly pointed out in the claims.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are not restrictive of the invention.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a perspective view of an electronic device of a first embodiment;

FIG. 2 is a cross-sectional view of the electronic device of the first embodiment;

FIG. 3 is a partial cross-sectional view of the electronic device of the first embodiment, in an enlarged view of a valve member;

FIG. 4 is a top view of the main body of the first embodiment;

FIG. 5 is a partial cross-sectional view of the electronic device once a support has been dissolved, in an enlarged view of a valve member of the first embodiment;

FIG. 6 is a cross-sectional view of the electronic device of a first modification to the first embodiment;

FIG. 7 is a partial cross-sectional view of an electronic device of a second embodiment, in an enlarged view of a valve member;

FIG. 8 is a partial top view of a main body of the second embodiment, in an enlarged view of the valve member;

FIG. 9 is a partial cross-sectional view of the electronic device of the second embodiment once supports have been dissolved, in an enlarged view of the valve member;

FIG. 10 is a partial cross-sectional view of an electronic device of a third embodiment, in an enlarged view of a valve member;

FIG. 11 is a partial top view of a main body of the third embodiment, in an enlarged view of the valve member;

FIG. 12 is a partial cross-sectional view of the electronic device of the third embodiment once supports have been dissolved, in an enlarged view of the valve member;

FIG. 13 is a partial cross-sectional view of an electronic device of the fourth embodiment, in an enlarged view of a valve member;

FIG. 14 is a partial top view of a main body of the fourth embodiment, in an enlarged view of the valve member;

FIG. 15 is a partial cross-sectional view of the electronic device of the fourth embodiment once volume changing bodies have shrunk, in an enlarged view of the valve member;

FIG. 16 is a cross-sectional view of an electronic device of a fifth embodiment;

FIG. 17 is a cross-sectional view of the electronic device of the fifth embodiment;

FIG. 18 is a top view of a second structure of the fifth embodiment;

FIG. 19 is a cross-sectional view of the electronic device of the fifth embodiment, once supports have been dissolved;

FIG. 20 is a cross-sectional view of an electronic device of a sixth embodiment;

FIG. 21 is a top view of a second structure of the sixth embodiment;

FIG. 22 is a cross-sectional view of the electronic device of the sixth embodiment, once volume changing bodies have expanded;

FIG. 23 is a cross-sectional view of an electronic device of a seventh embodiment;

FIG. 24 is a top view of a second structure of the seventh embodiment;

FIG. 25 is a cross-sectional view of the electronic device of the seventh embodiment, once volume changing bodies have expanded;

FIG. 26 is a partial cross-sectional view of an electronic device of an eighth embodiment, in an enlarged view of a volume changing body;

FIG. 27 is a partial top view of a main body of the eighth embodiment, in an enlarged view of the volume changing body;

FIG. 28 is a partial cross-sectional view of the electronic device of the eighth embodiment once the volume changing bodies have expanded, in an enlarged view of the volume changing body;

FIG. 29 is a top view of a main body of a ninth embodiment;

FIG. 30 is a cross-sectional view of an electronic device of the ninth embodiment;

FIG. 31 is a partial cross-sectional view of the electronic device of the ninth embodiment, in an enlarged view of electrodes;

FIG. 32 is a partial cross-sectional view of the electronic device of the ninth embodiment, in an enlarged view of volume changing bodies;

FIG. 33 is a partial cross-sectional view of the electronic device of the ninth embodiment, in an enlarged view of a through-hole;

FIG. 34 is a top view of a main body of a first modification to the ninth embodiment;

FIG. 35 is a cross-sectional view of an electronic device of the first modification to the ninth embodiment; and

FIG. 36 is a cross-sectional view of the electronic device of the first modification to the ninth embodiment.

DESCRIPTION OF EMBODIMENTS

Hereinafter, embodiments of a battery and an electronic device of the present invention will be described with reference to FIGS. 1-36.

First Embodiment

(Structure)

Referring to in FIG. 1, an electronic device 1 of a first embodiment is in a cylindrical shape. The electronic device 1 may be in any shape other than the cylindrical shape, such as spherical, disc, lenticular shape, or a columnar shape with the bottom in any shape other than the circular shape (e.g., oval, polygonal, or any other shape). Alternatively, the electronic device 1 may be in a rounded square columnar shape.

In this example, the electronic device 1 is an ingestible sensor. The electronic device 1 may be attached to a pharmaceutical preparation (in other words, dosage form), such as an encapsulated formulation or a tablet. Alternatively, the electronic device 1 may define at least a part of a pharmaceutical preparation, such as an encapsulated formulation or a tablet.

The electronic device 1 has a length (in other words, a height of the electronic device 1) between 1 mm and 20 mm, in the direction along the central axis, for example. The bottom of the electronic device 1 has a diameter between 1 mm and 20 mm, for example.

The electronic device 1 will be described using the right-hand Cartesian coordinates system defined by the X, Y,

and Z axes, as illustrated in FIGS. 1-5. The same Cartesian coordinates system as that in FIGS. 1-5 will be used in FIGS. 6-36 described later.

The Z axis extends along the direction of the height of the electronic device 1 (in other words, the central axis of the electronic device 1). The X and Y axes extend along the directions parallel to the bottom of the electronic device 1, respectively.

FIG. 2 illustrates the cross-section of the electronic device 1 on the plane passing Line II-II in FIG. 1, which passes through the central axis of the electronic device 1 and is perpendicular to the Y axis. The plane perpendicular to the Y axis may also be referred to as the ZX plane. As illustrated in FIG. 2, the electronic device 1 includes a main body 2 and a film 3.

In this example, the main body 2 is made from silicon (Si). At least a part of the main body 2 may be made from glass.

In this example, the main body 2 is in a pillar shape extending along the Z axis. In this example, the bottom of the main body 2 is in a square shape. The bottom of the main body 2 may be in any shape other than the square shape (e.g., circular, oval, rectangular, polygonal, or any other shape).

The film 3 coats the main body 2. The film 3 constitutes the surface of the electronic device 1. The film 3 is made from material that is to be dissolved responsive to pH. In this example, the film 3 is made from material that is to be dissolved upon contacting a fluid with pH lower than a predetermined threshold (e.g., pH of 5). The film 3 is made from material that is to be dissolved upon contacting a gastric fluid (in other words, gastrosoluble material), for example. At least a part of the film 3 may constitute a sugar coating. In this case, the sugar coating may contain sucrose, gelatin, hydroxypropylcellulose, or hydroxypropyl methylcellulose phthalate, as a main component.

For example, the gastrosoluble material has the main component selected from at least one of: calcium carbonate, magnesium carbonate, calcium phosphate, magnesium hydroxide, magnesium phosphate, gastrosoluble polyvinyl derivatives such as polyvinyl acetal diethylaminoacetate, methyl methacrylate-butyl methacrylate-dimethylaminoethyl methacrylate copolymer, methyl methacrylate-diethylaminoethyl methacrylate copolymer, and the like.

The electronic device 1 may include a padding member (not illustrated) between the main body 2 and the film 3 on the plane perpendicular to the Z axis (in other words, the XY plane). In this case, the padding member may be made from resin.

As illustrated in FIG. 2, the main body 2 includes a first space defining part 21 defining a first space SP1 inside the main body 2, and a second space defining part 22 defining a second space SP2 inside the main body 2. In this example, the part of the main body 2 where the first space defining part 21 is located constitutes a first layer. In this example, the part of the main body 2 where the second space defining part 22 is located constitutes a second layer different from the first layer.

The first space SP1 and the second space SP2 are in pillar shapes extending along the Z axis. In this example, the bottoms of the first space SP1 and the second space SP2 are in square shapes. The respective bottoms of the first space SP1 and the second space SP2 may be in any shapes other than the square shapes (e.g., circular, oval, rectangular, polygonal, or any other shapes). In this example, the bottom of the first space SP1 is in the same shape as that of the bottom of the second space SP2. The bottom of the first

space SP1 may be in any shape other than the shape of the bottom of the second space SP2.

In this example, the central axis of the first space SP1 coincides with the central axis of the second space SP2. The first space SP1 is on the positive direction side of the Z-axis relative to the second space SP2.

The electronic device 1 may include a retaining member made from porous material in the first space SP1. In this case, the porous material is preferably hydrophilic.

The main body 2 further includes a channel defining part 211 and multiple (eight in this example) through-hole parts 212, as illustrated in FIGS. 2-4. The electronic device 1 further includes a first electrode 213, a second electrode 214, a valve seat 215, multiple (two in this example) supports 216, and valve member 217. In this example, the main body 2, the film 3, the first electrode 213, the second electrode 214, the valve seat 215, the multiple supports 216, and the valve member 217 of the electronic device 1, constitute a battery (in other words, cell). In this example, the first electrode 213 and the second electrode 214 may also be referred to as the pair of electrodes.

FIG. 3 is a partial cross-sectional view of the electronic device 1 on the plane passing Line III-III in FIG. 4, in an enlarged view of the valve member 217 in FIG. 2. FIG. 4 is a diagram of the main body 2 when viewed toward the negative direction of the Z axis (in other words, a diagram viewing the top of the main body 2).

The channel defining part 211 defines a hole that passes through the wall, which defines the end face of the first space defining part 21 on the positive direction side of the Z axis, of the main body 2 in the Z-axis direction, and that is in a pillar shape extending along the Z axis. In other words, the hole defined by the channel defining part 211 communicates between the first space SP1 and the outside of the main body 2. In this example, the hole defined by the channel defining part 211 corresponds to a channel.

In this example, the bottom of the hole defined by the channel defining part 211 is in a rectangular shape. The bottom of the hole defined by the channel defining part 211 may be in any shape other than the rectangular shape (e.g., circular, oval, square, polygonal, or other shape). The hole defined by the channel defining part 211 may be shaped to be a part of a cone.

The long sides of the bottom of the hole defined by the channel defining part 211 have a length between 200 μm and 20 mm, for example. The short sides of the bottom of the hole defined by the channel defining part 211 have a length between 100 μm and 10 mm, for example.

In this example, the channel defining part 211 is located near the end part of the first space defining part 21 on the negative direction side of the X axis. The long sides and the short sides of the bottom of the hole defined by the channel defining part 211 extend along the Y axis and the X axis, respectively.

In this example, the channel defining part 211 and the first space defining part 21 are coated with hydrophilic films. The hydrophilic films are made from silicon dioxide, for example.

Each through-hole part 212 defines a hole that passes through the wall, which defines the end face of the first space defining part 21 on the positive direction side of the Z axis, of the main body 2 in the Z-axis direction, and that is in a pillar shape extending along the Z axis. In other words, the hole defined by each through-hole part 212 communicates between the first space SP1 and the outside of the main body 2.

In this example, the bottom of the hole defined by each through-hole part 212 is in a circular shape. The bottom of the hole defined by each through-hole part 212 may be in any shape other than the circular shape (e.g., oval, square, rectangular, polygonal, or other shape). The hole defined by each through-hole part 212 may be shaped to be a part of a cone.

In this example, the area of the bottom of the hole defined by each through-hole part 212 is smaller than the area of the bottom of the hole defined by the channel defining part 211. The bottom of the hole defined by each through-hole part 212 has a diameter between 2 μm and 200 μm , for example.

In this example, each through-hole part 212 is located near the end part of the first space defining part 21 on the positive direction side of the X axis. The multiple through-hole parts 212 are spaced apart at regular intervals along the Y axis. The number of the through-hole parts 212 may be any number other than eight.

In this example, each through-hole part 212 is coated with a water-repellent film. The water-repellent film is made from fluorocarbon resin (e.g., resin containing polytetrafluoroethylene as the main component), for example.

In this example, the first electrode 213 is made from magnesium. The first electrode 213 may be made from any material other than magnesium (e.g., zinc, alloy, or the like). Alternatively, the first electrode 213 may be a film stack where multiple layers respectively made from different materials are stacked.

The first electrode 213 is in a planer shape that is parallel to the XY plane. The first electrode 213 has a thickness between 100 nm and 2 mm, for example. In this example, the first electrode 213 is in a rectangular shape. The first electrode 213 may be in any shape other than the rectangular shape (e.g., circular, oval, square, polygonal, or other shape).

The first electrode 213 contacts the end face of the first space defining part 21 on the negative direction side of the Z axis.

In this example, the area of the first electrode 213 is slightly smaller than the half of the area of the end face of the first space defining part 21 on the negative direction side of the Z axis. In this example, the long sides and the short sides of the first electrode 213 extend along the Y axis and the X axis, respectively.

In this example, the second electrode 214 is made from platinum. The second electrode 214 may be made from any material other than platinum (e.g., copper chloride (CuCl), silver chloride (AgCl), alloy, or the like). Alternatively, the second electrode 214 may be a film stack where multiple layers respectively made from different materials are stacked.

The second electrode 214 is in a planer shape that is parallel to the XY plane. The second electrode 214 has a thickness between 10 nm and 2 mm, for example. In this example, the second electrode 214 is in a rectangular shape. The second electrode 214 may be in any shape other than the rectangular shape (e.g., circular, oval, square, polygonal, or other shape).

The second electrode 214 contacts the end face of the first space defining part 21 on the negative direction side of the Z axis.

In this example, the area of the second electrode 214 is slightly smaller than the half of the area of the end face of the first space defining part 21 on the negative direction side of the Z axis. In this example, the long sides and the short sides of the second electrode 214 extend along the Y axis and the X axis, respectively.

In this example, the first electrode **213** is on the negative direction side of the X axis, relative to the center in the X-axis direction of the end face of the first space defining part **21** on the negative direction side of the Z axis. In this example, the second electrode **214** is on the positive direction side of the X axis, relative to the center in the X-axis direction in the end face of the first space defining part **21** on the negative direction side of the Z axis. In other words, the first electrode **213** and the second electrode **214** are separated from each other.

In this example, the materials of the first electrode **213** and the second electrode **214** are selected such that electric power is generated with a gastric fluid functioning as an electrolyte once a gastric fluid has been introduced to the first space SP1.

In this example, the valve seat **215** is made from metal. The valve seat **215** may be made from material other than metal (e.g., resin containing polyimide as a main component and the like).

The valve seat **215** is in a planer shape that is parallel to the XY plane. The valve seat **215** has a thickness between 10 nm and 10 μ m, for example. The valve seat **215** contacts the end face of the surfaces of the main body **2** on the positive direction side of the Z axis.

The valve seat **215** has a predetermined width, and extends along the edge of the channel defining part **211** on the positive direction side of the Z axis. The edge of the channel defining part **211** on the positive direction side of the Z axis may also be referred to as the outer edge of the end face of the hole defined by the channel defining part **211** on the positive direction side of the Z axis. Further, the edge of the channel defining part **211** on the positive direction side of the Z axis may also be referred to as the outer edge of the opening of the hole defined by the channel defining part **211** in the end face of the surfaces of the main body **2** on the positive direction side of the Z axis.

In other words, the valve seat **215** has a hole that has an shape on the XY plane coinciding with the shape of the hole defined by the channel defining part **211** on the XY plane, and passes through in the Z-axis direction.

Each support **216** is made from material that is to be dissolved responsive to pH. In this example, each support **216** is made from material that is to be dissolved upon contacting a fluid with a pH lower than a predetermined threshold (e.g., pH of 5). Each support **216** is made from material that is to be dissolved upon contacting a gastric fluid (in other words, gastrosoluble material), for example.

Each support **216** is in a pillar shape extending along the Z axis. In this example, the bottom of each support **216** is in a rectangular shape. The bottom of each support **216** may be in any shape other than the rectangular shape (e.g., circular, oval, square, polygonal, or other shape).

For example, each support **216** has a length (in other words, the height of the support **216**) between 10 μ m and 1 mm in the Z-axis direction. In this example, the height of each support **216** is greater than the thickness of the valve seat **215**.

Each support **216** contacts the end face of the surfaces of the main body **2** on the positive direction side of the Z axis. In this example, the long sides and the short sides of each support **216** extend along the X axis and the Y axis, respectively.

Each support **216** is on the positive direction side of the X axis relative to the channel defining part **211**. One of the two supports **216** is on the positive direction side of the Y axis relative to the channel defining part **211**, and the other is on the negative direction side of the Y axis relative to the

channel defining part **211**. In other words, the two supports **216** are separated from each other.

The supports **216** may have positions and sizes different from the position and the size illustrated in FIG. 4. The supports **216** may be located in predetermined regions of the outer periphery of the valve seat **215**, for example.

The number of the supports **216** may be any number other than two.

In this example, the supports **216** are configured such that the supports **216** are dissolved completely once a fluid has been introduced to the first space SP1 through the hole defined by the channel defining part **211**, when the pH external to the first space SP1 is lower than the above-described threshold.

The valve member **217** is made from silicon (Si). The valve member **217** may be made from any material (e.g., metal, resin, or the like) other than silicon.

The valve member **217** is in a planer shape that is parallel to the XY plane while not being elastically deformed. The valve member **217** has a thickness between 100 nm and 200 μ m, for example.

In this example, the valve member **217** is in a rectangular shape while not being elastically deformed. The valve member **217** may be in any shape other than the rectangular shape (e.g., circular, oval, square, polygonal, or other shape) while not being elastically deformed. In this example, the long sides and the short sides of the valve member **217** extend along the Y axis and the X axis, respectively, while the valve member **217** is not elastically deformed.

In the X-axis direction, the valve member **217** extends from the negative direction side of the X axis relative to the valve seat **215**, to the positive direction side of the X axis relative to the valve seat **215** (in this example, the positive direction side of the X axis relative to the supports **216**).

In the Y-axis direction, the valve member **217** extends from the negative direction side of the Y axis relative to the valve seat **215**, to the positive direction side of the Y axis relative to the valve seat **215**. In this example, in the Y-axis direction, the valve member **217** extends from the negative direction side of the Y axis relative to the support **216** on the negative direction side of the Y axis from among the two supports **216**, to the positive direction side of the Y axis relative to the support **216** on the positive direction side of the Y axis from among the two supports **216**.

In other words, when the main body **2** is viewed toward the negative direction of the Z axis, the valve member **217** covers the hole defined by the channel defining part **211**, the valve seat **215**, and the supports **216**.

The part of the valve member **217** on the negative direction side of the X axis relative to the valve seat **215** contacts the end face of the surfaces of the main body **2** on the positive direction side of the Z axis. In this example, the part of the valve member **217** on the negative direction side of the X axis relative to the valve seat **215** is secured to the end face of the surfaces of the main body **2** on the positive direction side of the Z axis.

As illustrated in FIGS. 2 and 3, the valve member **217** is supported by the supports **216**, with being curved by an elastic deformation such that a portion of the valve member **217** is displaced further to the positive direction side of the Z axis as the portion approaches, in the X-axis direction, the end of the valve member **217** on the positive direction side of the X axis.

In other words, as illustrated in FIG. 3, the valve member **217** undergoes the resiliency (in other words, restoring force) F1 generated against the elastic deformation. In this example, the resiliency F1 can be interpreted as the force to

restore the valve member **217** to its unbent state (in other words, the force to restore the valve member **217** to be parallel to the XY plane). In this example, the resiliency **F1** can also be interpreted as the force to displace the end of the valve member **217** on the positive direction side of the X axis to the negative direction of the Z axis.

In the manner as described above, the valve member **217** is biased toward the valve seat **215**, and is supported by the supports **216** at the position away from the valve seat **215**.

As illustrated in FIG. 5, once the supports **216** have been dissolved, the valve member **217** is restored to be parallel to the XY plane by the resiliency **F1**. As a result, the valve member **217** contacts the valve seat **215**. In this example, the valve member **217** is pressed against the valve seat **215**. As a result, the valve member **217** closes the channel communicating between the first space **SP1** and the outside of the main body **2**. The term “closing the channel” may also be referred to as “blocking the channel”.

In this example, the valve seat **215**, the supports **216**, and the valve member **217** correspond to a valve that closes the channel communicating between the first space **SP1** and the outside of the main body **2** responsive to pH. In this example, the valve closes the channel communicating between the first space **SP1** and the outside of the main body **2** once a fluid has been introduced to the first space **SP1** through the hole defined by the channel defining part **211**, when the pH external to the first space **SP1** is lower than the above-described threshold.

Additionally, as illustrated in FIG. 2, the electronic device **1** includes a first through-hole part **221**, a second through-hole part **222**, a first terminal **223**, a second terminal **224**, a first conductor **225**, a second conductor **226**, and a circuit **227**.

The first through-hole part **221** defines a hole that passes through the wall, which defines the end face of the first space defining part **21** on the negative direction side of the Z axis and defines the end face of the second space defining part **22** on the positive direction side of the Z axis, of the main body **2** in the Z-axis direction, and is in a pillar shape extending along the Z axis.

In this example, the bottom of the hole defined by the first through-hole part **221** is in a circular shape. The bottom of the hole defined by the first through-hole part **221** may be in any shape other than the circular shape (e.g., oval, square, rectangular, polygonal, or other shape). The hole defined by the first through-hole part **221** may be shaped to be a part of a cone.

The outer edge of the first through-hole part **221** on the XY plane is located inside the outer edge of the first electrode **213** on the XY plane. In this example, the first through-hole part **221** is located at the center part of the first electrode **213** on the XY plane.

The second through-hole part **222** defines a hole that passes through the wall, which defines the end face of the first space defining part **21** on the negative direction side of the Z axis and defines the end face of the second space defining part **22** on the positive direction side of the Z axis, of the main body **2** in the Z-axis direction, and is in a pillar shape extending along the Z axis.

In this example, the bottom of the hole defined by the second through-hole part **222** is in a circular shape. The bottom of the hole defined by the second through-hole part **222** may be in any shape other than the circular shape (e.g., oval, square, rectangular, polygonal, or other shape). The hole defined by the second through-hole part **222** may be shaped to be a part of a cone.

The outer edge of the second through-hole part **222** on the XY plane is located inside the outer edge of the second electrode **214** on the XY plane. In this example, the second through-hole part **222** is located at the center part of the second electrode **214** on the XY plane.

In this example, the first terminal **223** is made from metal. The first terminal **223** is in a planer shape that is parallel to the XY plane. The first terminal **223** contacts the end face of the second space defining part **22** on the positive direction side of the Z axis.

The outer edge of the first terminal **223** on the XY plane is located outside the outer edge of the first through-hole part **221** on the XY plane. In this example, the first terminal **223** is located such that the first through-hole part **221** is located at the center part of the first terminal **223** on the XY plane.

In this example, the second terminal **224** is made from metal. The second terminal **224** is in a planer shape that is parallel to the XY plane. The second terminal **224** contacts the end face of the second space defining part **22** on the positive direction side of the Z axis.

The outer edge of the second terminal **224** on the XY plane is located outside the outer edge of the second through-hole part **222** on the XY plane. In this example, the second terminal **224** is located such that the second through-hole part **222** is located at the center part of the second terminal **224** on the XY plane.

In this example, the first conductor **225** is made from metal. The first conductor **225** is filled in the hole defined by the first through-hole part **221**, thereby connecting the first electrode **213** and the first terminal **223**.

In this example, the second conductor **226** is made from metal. The second conductor **226** is filled in the hole defined by the second through-hole part **222**, thereby connecting the second electrode **214** and the second terminal **224**.

The circuit **227** is connected to the first terminal **223** and the second terminal **224**. The circuit **227** is energized by the potential difference induced between the first electrode **213** and the second electrode **214** when a fluid acting as an electrolyte enters the first space **SP1**. In this example, inducing the potential difference between the first electrode **213** and the second electrode **214** corresponds to generating electric power.

For example, the circuit **227** includes at least one of a sensing circuit and a communication circuit.

The sensing circuit senses a physical quantity. The physical quantity is temperature, pH, or concentration of a target, for example. The target is a digestive fluid (e.g., gastric fluid, intestinal fluid, pancreatic fluid, or the like), blood, indigenous bacteria, or infectious material (e.g., bacteria, virus, or the like), for example. The concentration of the target equal to or greater than a predetermined threshold can be interpreted that the target is present.

The communication circuit wirelessly communicates with an apparatus external to the electronic device **1**. For example, when the circuit **227** includes the sensing circuit and the communication circuit, the communication circuit sends a signal indicative of a physical quantity sensed by the sensing circuit.

(Operations)

Next, operations of the electronic device **1** will be described.

First, the electronic device **1** is introduced to the mouth of a living body (e.g., human body). The electronic device **1** is then swallowed by the living body and reaches the esophagus. Since the film **3** is not dissolved in saliva, no fluid enters the first space **SP1** in the mouth and the esophagus.

Thereafter, the electronic device **1** reaches the stomach. As a result, the pH external to the electronic device **1** declines below the above-described threshold. This causes the film **3** to be dissolved. As a result, gastric fluid enters the first space SP1 through the hole defined by the channel

defining part **211**. Any gas remaining in the first space SP1 is exhausted through the through-hole parts **212**.

As a result, the gastric fluid introduced to the first space SP1 functions as an electrolyte, and hence the battery in the electronic device **1** generates electric power. The circuit **227** is energized by the generated electric power.

Once the gastric fluid has been introduced to the first space SP1, the supports **216** are dissolved completely.

The valve member **217** is then restored to be parallel to the XY plane by the resiliency. This causes the valve member **217** to be pressed against the valve seat **215**. As a result, the valve member **217** closes the channel communicating between the first space SP1 and the outside of the main body **2**.

This can prevent any matters other than the gastric fluid (e.g., fluid with pH different from that of gastric fluid, solid matter, or the like) from entering the first space SP1. As a result, a decline in the power output can be suppressed.

Thereafter, the electronic device **1** reaches the intestines. Since the channel communicating between the first space SP1 and the outside of the main body **2** is closed, an entry of any matters other than the gastric fluid to the first space SP1 is prevented in the digestive tract downstream to the stomach. As a result, a decline in the power output can be suppressed in the digestive tract downstream to the stomach.

Thereafter, the electronic device **1** is excreted from the living body.

As set forth above, the electronic device **1** of the first embodiment has the main body **2** including the first space SP1 defined therein and the channel communicating between the outside and the first space SP1, and includes the pair of electrodes **213**, **214** adjoining the first space SP1 and the valve that closes the channel responsive to pH.

In accordance with the above configuration, once the electronic device **1** has been introduced into the digestive tract in a living body, a fluid in the digestive tract enters the first space SP1 through the channel. The fluid introduced to the first space SP1 functions as an electrolyte, and the battery in the electronic device **1** generates electric power. The valve closes the channel responsive to pH. This prevents matters with a pH different from that of the electrolyte-acting fluid (e.g., fluid, solid matter, or the like with a pH different from that of the electrolyte-acting fluid), from entering the first space SP1. As a result, a decline in the power output can be suppressed.

Furthermore, in the electronic device **1** of the first embodiment, the valve includes the valve seat **215**, the supports **216** that are dissolved responsive to pH, and the valve member **217** that is biased toward the valve seat **215**, supported by the supports **216** at the location distant from the valve seat **215**, and contacts the valve seat **215** after dissolution of the supports **216**, thereby closing the channel.

In accordance with the above configuration, the supports **216** are dissolved in response to the change in pH. This causes the valve member **217** to contact the valve seat **215**, thereby closing the channel.

Further, in the electronic device **1** of the first embodiment, when the pH external to the first space SP1 is lower than the predetermined threshold, the valve closes the channel once the fluid has been introduced to the first space SP1 through the channel.

In the meantime, once the electronic device **1** has been introduced to the stomach, the pH external to the first space SP1 declines below the above-described threshold. In this case, gastric fluid enters the first space SP1 through the channel. The gastric fluid introduced to the first space SP1 functions as an electrolyte, and the battery in the electronic device **1** generates electric power. The valve then closes the channel. Therefore, an entry of any matters other than the gastric fluid to the first space SP1 is prevented in the digestive tract downstream to the stomach. As a result, a decline in the power output can be suppressed in the digestive tract downstream to the stomach.

Furthermore, the electronic device **1** of the first embodiment includes the film **3** that coats the main body **2** and, is dissolved responsive to pH.

In accordance with the above configuration, it is possible to prevent any fluid with a pH different from that of the fluid used as an electrolyte (e.g., liquid, such as water, that is introduced to the digestive tract together with the electronic device **1**, saliva, or the like), from entering the first space SP1 prior to the fluid used as an electrolyte (gastric fluid, in this example). This ensures that the fluid used as an electrolyte enters the first space SP1, which in turn ensures that the battery generates electric power in a reliable manner.

Furthermore, in the electronic device **1** of the first embodiment, the battery is disposed at the first layer, whereas the circuit **227** is disposed at the second layer different from the first layer.

In accordance with the above configuration, it is possible to increase the areas of the electrodes **213**, **214**, as compared to the configuration where the battery and the circuit **227** are disposed at the same layer. This increases the power output.

The film **3** may coat only a portion of the main body **2**. In this case, the film **3** may coat a portion of the main body **2** so as to cover the gap between the valve member **217** and the main body **2**. Also in such a configuration, the film **3** may also coat a portion of the main body **2** so as to obstruct the through-hole parts **212**.

Alternatively, the electronic device **1** may have no film **3**. In this case, the electronic device **1** may use a fluid (e.g., a liquid swallowed with the electronic device **1**) entering the digestive tract together with the electronic device **1**, as an electrolyte. In this case, the supports **216** may be configured to facilitate quick completion of the dissolution of the supports **216**, when the pH external to the first space SP1 is lower than the above-described threshold.

The supports **216** may be made from material that is dissolved upon contacting a fluid with a pH higher than a predetermined threshold (e.g., pH of 4). In this case, the supports **216** may be made from material that is dissolved upon contacting the pancreatic fluid, for example. Alternatively, in such a configuration, for example, each support **216** may be made from material (in other words, enteric material) that is dissolved upon contacting an intestinal fluid, for example.

The enteric material contains at least one of: hydroxypropyl methylcellulose phthalate, cellulose acetate phthalate, polyvinyl acetate phthalate, styrene-maleic anhydride copolymer, methacrylate-methyl methacrylate copolymer, carboxymethyl ethyl cellulose, and the like, as a main component, for example.

For example, once the electronic device **1** reaches the duodenum or the small intestine, the pH external to the electronic device **1** exceeds the above-described threshold. In this case, therefore, once the electronic device **1** reaches the duodenum or the small intestine, the supports **216** are dissolved completely. As a result, the valve member **217**

closes the channel communicating between the first space SP1 and the outside of the main body 2.

First Modification to First Embodiment

Next, an electronic device of a first modification to the first embodiment will be described. The electronic device of the first modification to the first embodiment is different from the electronic device of the first embodiment in that multiple batteries are provided. Descriptions will be given focusing on that difference. In the descriptions of the first modification to the first embodiment, elements denoted by like reference symbols denote the same or substantially similar elements used in the first embodiment.

Referring to FIG. 6, an electronic device 1A of the first modification to the first embodiment includes a main body 2A, in place of the main body 2 of the first embodiment.

The main body 2A includes a third space defining part 21A defining a third space SP3 inside the main body 2A, in addition to a first space defining part 21 and a second space defining part 22. In this example, the part of the main body 2A where the third space defining part 21A is disposed defines a third layer. In other words, the third layer is a layer that is disposed opposite to the first layer relative to the second layer, and is different from the first layer and the second layer.

The third space SP3 is in a pillar shape extending along the Z axis. In this example, the bottom of the third space SP3 is in a square shape. The bottom of the third space SP3 may be in any shape other than the square shape (e.g., circular, oval, rectangular, polygonal, or any other shape). In this example, the bottom of the third space SP3 is in the same shape as that of the bottom of the first space SP1. The bottom of the third space SP3 may be in any shape other than that of the bottom of the first space SP1.

In this example, the central axis of the third space SP3 coincides with the central axis of the first space SP1 and the central axis of the second space SP2. In addition, the third space SP3 is on the negative direction side of the Z axis relative to the second space SP2.

The electronic device 1A may include a retaining member made from porous material in the third space SP3. In this case, the porous material is preferably hydrophilic.

In addition to the elements provided in the main body 2, the main body 2A further including a channel defining part 211A and multiple (eight in this example) through-hole parts 212A. In addition to the elements provided in the electronic device 1, the electronic device 1A further includes a third electrode 213A, a fourth electrode 214A, a valve seat 215A, multiple (two in this example) supports 216A, a valve member 217A, a third through-hole part 221A, a fourth through-hole part 222A, a third terminal 223A, a fourth terminal 224A, a third conductor 225A, and a fourth conductor 226A.

In this example, the main body 2A, the film 3, the first electrode 213, the second electrode 214, the valve seat 215, the multiple supports 216, and the valve member 217 of the electronic device 1A constitute a first battery. In this example, the main body 2A, the film 3, the third electrode 213A, the fourth electrode 214A, the valve seat 215A, the multiple supports 216A, and the valve member 217A of the electronic device 1A constitute a second battery. In this example, the third electrode 213A and the fourth electrode 214A may also be referred to as the pair of electrodes.

The second battery is configured similarly to the first battery, except for the fact that they are disposed plane

symmetrically relative to the XY plane (in other words, the reference plane) passing through the center of the main body 2A in the Z-axis direction.

Furthermore, the third through-hole part 221A, the fourth through-hole part 222A, the third terminal 223A, the fourth terminal 224A, the third conductor 225A, and the fourth conductor 226A are configured similarly to the first through-hole part 221, the second through-hole part 222, the first terminal 223, the second terminal 224, the first conductor 225, and the second conductor 226, respectively, except for the fact that they are disposed plane symmetrically relative to the reference plane.

In this example, the circuit 227 is connected to the first terminal 223 and the second terminal 224, and is also connected to the third terminal 223A and the fourth terminal 224A. The circuit 227 is energized by both the potential difference induced between the first electrode 213 and the second electrode 214 when an electrolyte-acting fluid enters the first space SP1, and the potential difference induced between the third electrode 213A and the fourth electrode 214A when the electrolyte-acting fluid enters the third space SP3. In this example, the first terminal 223 and the second terminal 224, and the third terminal 223A and the fourth terminal 224A are connected to the circuit 227 in series.

As set forth above, in accordance with the electronic device 1A of the first modification to the first embodiment, effects and advantages similar to those of the electronic device 1 of the first embodiment are achieved.

Further, the electronic device 1A of the first modification to the first embodiment includes the first battery and the second battery. Additionally, the second battery is disposed at the third layer that is different from the first layer and the second layer, opposite to the first layer relative to the second layer.

In accordance with the above configuration, it is possible to increase the areas of the electrodes 213, 214, 213A, 214A, as compared to the configuration where the second battery is disposed at the same layer as the first battery or the circuit 227. This increases the power output.

Further, in accordance with the electronic device 1A, the first battery and the second battery contain the electrolyte in the respective spaces. Therefore, it is possible to connect the first battery and the second battery in series. As a result, voltage supplied to the circuit 227 is increased.

Second Embodiment

Next, an electronic device of a second embodiment will be described. The electronic device of the second embodiment is different from the electronic device of the first embodiment in terms of the valve member and the supports. Descriptions will be given focusing on that difference. In the descriptions of the second embodiment, elements denoted by like reference symbols denote the same or substantially similar elements used in the first embodiment.

Referring to FIGS. 7-9, an electronic device 1 of the second embodiment includes multiple (two in this example) supports 216B and a valve member 217B, in place of the multiple supports 216 and the valve member 217 of the first embodiment.

FIG. 7 is a partial cross-sectional view of the electronic device 1 on the plane passing Line VII-VII in FIG. 8, in an enlarged view of the valve member 217B. FIG. 8 is an enlarged view of the area in the vicinity of the valve member 217B, when the main body 2 is viewed toward the negative direction of the Z axis. FIG. 9 is a partial cross-sectional view of the electronic device 1 on the plane passing Line

VII-VII in FIG. 8 once the supports 216B have been dissolved, in an enlarged view of the valve member 217B.

The valve member 217B is in a planer shape that is parallel to the XY plane while not being elastically deformed. The valve member 217B has a thickness between 100 nm and 200 μm, for example.

In this example, the valve member 217B is in a rectangular shape while not being elastically deformed. The valve member 217B may be in any shape other than the rectangular shape (e.g., circular, oval, square, polygonal, or other shape) while not being elastically deformed. In this example, the long sides and the short sides of the valve member 217B extend along the Y axis and the X axis, respectively, while the valve member 217B is not elastically deformed.

As illustrated in FIG. 8, in the X-axis direction, the valve member 217B extends from the negative direction side of the X axis relative to the valve seat 215, to the positive direction side of the X axis relative to the valve seat 215. In the Y-axis direction, the valve member 217B extends from the negative direction side of the Y axis relative to the valve seat 215, to the positive direction side of the Y axis relative to the valve seat 215.

In other words, when the main body 2 is viewed toward the negative direction of the Z axis, the valve member 217B covers the hole defined by the channel defining part 211, and the valve seat 215.

Both of the end parts in the X-axis direction of the valve member 217B contact the end face of the surfaces of the main body 2 on the positive direction side of the Z axis. In this example, both of the end parts in the X-axis direction of the valve member 217B are secured to end face of the surfaces of the main body 2 on the positive direction side of the Z axis.

Each support 216B is made from material that is to be dissolved responsive to pH. In this example, each support 216B is made from material that is to be dissolved upon contacting a fluid with a pH lower than a predetermined threshold (e.g., pH of 5). Each support 216B is made from gastrosoluble material, for example. Each support 216B may be made from material that is dissolved upon contacting a fluid with a pH higher than a predetermined threshold (e.g., pH of 4). In this case, each support 216B may be made from enteric material, for example.

Each support 216B is in a planer shape. Each support 216B has a thickness between 10 nm and 200 μm, for example.

As illustrated in FIG. 8, in the X-axis direction, each support 216B extends from the part of the valve member 217B secured to the surface of the main body 2, to the center part of the valve member 217B in the X-axis direction (in this example, in the vicinity of the channel defining part 211). In the Y-axis direction, each support 216B extends from the edge of the valve member 217B on the negative direction side of the Y axis, to the edge of the valve member 217B on the positive direction side of the Y axis.

Each support 216B is secured to the valve member 217B, while the entire end face of the surfaces of that support 216B on the negative direction side of the Z axis contacts the end face of the surfaces of the valve member 217B on the positive direction side of the Z axis.

As illustrated in FIG. 7, the support 216B of the two supports 216B on the negative direction side of the X axis is in a curved shape such that a portion of the support 216B is displaced further to the positive direction side of the Z axis as the portion approaches, in the X-axis direction, the end of the support 216B on the positive direction side of the X axis. The support 216B of the two supports 216B on the positive

direction side of the X axis is in a curved shape such that a portion of the support 216B is displaced further to the positive direction side of the Z axis as the portion approaches, in the X-axis direction, the end of the support 216B on the negative direction side of the X axis.

In other words, each of the supports 216B is in the curved shape such that a portion of each support 216B is displaced further to the positive direction side of the Z axis as the portion approaches, in the X-axis direction, the center part of the valve member 217B in the X-axis direction.

As a result, the valve member 217B is supported by the supports 216B, with being curved by an elastic deformation, such that a portion of the valve member 217B is displaced further to the positive direction side of the Z axis as the portion approaches, in the X-axis direction, the center part of the valve member 217B in the X-axis direction.

In other words, as illustrated in FIG. 7, the valve member 217B undergoes the resiliency F2 generated against the elastic deformation. In this example, the resiliency F2 can be interpreted as the force to restore the valve member 217B to its unbenet state (in other words, the valve member 217B to be parallel to the XY plane). In this example, the resiliency F2 can also be interpreted as the force to displace the center part of the valve member 217B to the negative direction of the Z axis.

In the manner as described above, the valve member 217B is biased toward the valve seat 215, and is supported by the supports 216B at the location distant from the valve seat 215.

As illustrated in FIG. 9, once the supports 216B have been dissolved, the valve member 217B is restored to be parallel to the XY plane by the resiliency F2. As a result, the valve member 217B contacts the valve seat 215. In this example, the valve member 217B is pressed against the valve seat 215. As a result, the valve member 217B closes the channel communicating between the first space SP1 and the outside of the main body 2.

The supports 216B may have positions and sizes different from the position and the size illustrated in FIG. 8. The number of the supports 216B may be any number other than two.

In this example, the supports 216B are configured such that the supports 216B are dissolved completely once a fluid has been introduced to the first space SP1 through the hole defined by the channel defining part 211, when the pH external to the first space SP1 is lower than the above-described threshold.

The electronic device 1 of the second embodiment operates in the similar manner to the electronic device 1 of the first embodiment. Accordingly, effects and advantages similar to those of the electronic device 1 of the first embodiment are also achieved by the electronic device 1 of the second embodiment.

Third Embodiment

Next, an electronic device of a third embodiment will be described. The electronic device of the third embodiment is different from the electronic device of the first embodiment in terms of the valve member and the supports. Descriptions will be given focusing on that difference. In the descriptions of the third embodiment, elements denoted by like reference symbols denote the same or substantially similar elements used in the first embodiment.

Referring to FIGS. 10-12, an electronic device 1 of the third embodiment includes multiple (four in this example)

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supports **216C** and a valve member **217C**, in place of the multiple supports **216** and the valve member **217** of the first embodiment.

FIG. **10** is a partial cross-sectional view of the electronic device **1** on the plane passing Line XII-XII in FIG. **11**, in an enlarged view of the valve member **217C**. FIG. **11** is an enlarged view of the area in the vicinity of the valve member **217C**, when the main body **2** is viewed toward the negative direction of the Z axis. FIG. **12** is a partial cross-sectional view of the electronic device **1** once the supports **216C** have been dissolved, on the plane passing Line XII-XII in FIG. **11**, in an enlarged view of the valve member **217C**.

The valve member **217C** includes a base **217C1** and multiple (four in this example) legs **217C2**.

The base **217C1** is in a planer shape that is parallel to the XY plane. The base **217C1** has a thickness between 2 μm and 200 μm , for example.

In this example, the base **217C1** is in a rectangular shape. The base **217C1** may be in any shape other than the rectangular shape (e.g., circular, oval, square, polygonal, or other shape). In this example, the long sides and the short sides of the base **217C1** extend along the Y axis and the X axis, respectively.

As illustrated in FIG. **11**, in the X-axis direction, the base **217C1** extends from the negative direction side of the X axis relative to the valve seat **215**, to the positive direction side of the X axis relative to the valve seat **215**. In the Y-axis direction, the base **217C1** extends from the negative direction side of the Y axis relative to the valve seat **215**, to the positive direction side of the Y axis relative to the valve seat **215**.

In other words, when the main body **2** is viewed toward the negative direction of the Z axis, the base **217C1** covers the hole defined by the channel defining part **211**, and the valve seat **215**.

Each leg **217C2** is in a planer shape. In this example, each leg **217C2** has the same thickness as the thickness of the base **217C1**. Each leg **217C2** may have a thickness different from the thickness of the base **217C1**.

The four legs **217C2** extend from the respective sides of the base **217C1** in the four directions. In this example, the width of each leg **217C2** is smaller than the length of the side that adjoins the proximal end of the legs **217C2**, of the sides of the base **217C1** in the four directions. In this example, the proximal end of each leg **217C2** is located at the center part of the side that adjoins that proximal end of the sides of the base **217C1** in the four directions.

Each leg **217C2** is bent. The distal end of each leg **217C2** contacts end face of the surfaces of the main body **2** on the positive direction side of the Z axis. In this example, the distal end of each leg **217C2** is secured to end face of the surfaces of the main body **2** on the positive direction side of the Z axis.

In the manner as described above, the multiple legs **217C2** support the base **217C1**.

The part of each leg **217C2** between the bent portion of the leg **217C2** and the proximal end of the leg **217C2** is curved such that it is displaced further to the negative direction side of the Z axis as the part approaches the proximal end, in a state that the leg **217C2** is not elastically deformed. In this example, in a state that each leg **217C2** is not elastically deformed, the position of the proximal end of the leg **217C2** in the Z-axis direction is located at substantially the same position as that of the valve seat **215** (e.g., the position slightly on the negative direction side of the Z axis relative to the valve seat **215**).

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Each support **216C** is made from material that is to be dissolved responsive to pH. In this example, each support **216C** is made from material that is to be dissolved upon contacting a fluid with a pH lower than a predetermined threshold (e.g., pH of 5). Each support **216C** is made from gastrosoluble material, for example. Each support **216C** may be made from material that is dissolved upon contacting a fluid with a pH higher than a predetermined threshold (e.g., pH of 4). In this case, each support **216C** may be made from enteric material, for example.

Each support **216C** is in a planer shape that is parallel to the XY plane. Each support **216C** has a thickness between 10 nm and 200 μm , for example.

As illustrated in FIG. **11**, each support **216C** has the same width as that of the legs **217C2**. Each support **216C** is disposed between the portion where the corresponding leg **217C2** bends and the proximal end of that leg **217C2**.

Each support **216C** is secured to the corresponding leg **217C2**, with the entire end face of the surfaces of that support **216C** on the positive direction side of the Z axis contacting the end face of the surface of the leg **217C2** on the negative direction side of the Z axis.

In the manner as described above, the proximal end of each leg **217C2** is located at substantially the same position as that of the bent portion of that leg **217C2**, in the Z-axis direction. Therefore, in a state that the part of each leg **217C2** between the bent portion of the leg **217C2** and the proximal end of the leg **217C2** is not curved by being elastically deformed, the base **217C1** of the valve member **217C** is supported by each support **216C**.

In other words, as illustrated in FIG. **10**, the part of each leg **217C2** between the bent portion of the leg **217C2** and the proximal end of the leg **217C2** undergoes the resiliency **F3** generated against the elastic deformation. In this example, the resiliency **F3** can be interpreted as the force to restore the part of each leg **217C2** between the bent portion of the leg **217C2** and the proximal end of the leg **217C2** to the curved state (in other words, the state where the position of the proximal end in the Z-axis direction is at substantially the same position as that of the valve seat **215**). In this example, the resiliency **F3** can also be interpreted as the force to displace the base **217C1** to the negative direction of the Z axis.

In the manner as described above, the base **217C1** of the valve member **217C** is biased toward the valve seat **215**, and is supported by the supports **216C** at the location distant from the valve seat **215**.

As illustrated in FIG. **12**, once the supports **216C** have been dissolved, the part of each leg **217C2** between the bent portion of the leg **217C2** and the proximal end of the leg **217C2** is restored to the curved state (in other words, the state where the position of the proximal end in the Z-axis direction is at substantially the same position as that of the valve seat **215**) by the resiliency **F3**. As a result, the base **217C1** of the valve member **217C** contacts the valve seat **215**. In this example, the base **217C1** of the valve member **217C** is pressed against the valve seat **215**. As a result, the valve member **217C** closes the channel communicating between the first space **SP1** and the outside of the main body **2**.

The supports **216C** may have positions and sizes different from the positions and the sizes illustrated in FIG. **11**. The number of the supports **216C** may be any number other than four.

In this example, each support **216C** is configured such that the supports **216C** are dissolved completely once a fluid has been introduced to the first space **SP1** through the hole

defined by the channel defining part **211**, when the pH external to the first space SP1 is lower than the above-described threshold.

The electronic device **1** of the third embodiment operates in the similar manner to the electronic device **1** of the first embodiment. Accordingly, effects and advantages similar to those of the electronic device **1** of the first embodiment are also achieved by the electronic device **1** of the third embodiment.

Fourth Embodiment

Next, an electronic device of a fourth embodiment will be described. The electronic device of the fourth embodiment is different from the electronic device of the first embodiment in that volume changing bodies that undergo volume changes responsive to pH are used, in place of the supports that are to be dissolved responsive to pH. Descriptions will be given focusing on that difference. In the descriptions of the fourth embodiment, elements denoted by like reference symbols denote the same or substantially similar elements used in the first embodiment.

Referring to FIGS. **13-15**, an electronic device **1** of the fourth embodiment includes a valve member **217D** and multiple (four in this example) volume changing bodies **218D**, in place of the multiple supports **216** and the valve member **217** of the first embodiment.

FIG. **13** is a partial cross-sectional view of the electronic device **1** on the plane passing Line XIII-XIII in FIG. **14**, in an enlarged view of the valve member **217D**. FIG. **14** is an enlarged view of the area in the vicinity of the valve member **217D**, when the main body **2** is viewed toward the negative direction of the Z axis. FIG. **15** is a partial cross-sectional view of the electronic device **1** when the volume changing bodies **218D** shrink, on the plane passing Line XIII-XIII in FIG. **14**, in an enlarged view of the valve member **217D**.

The valve member **217D** is in a planer shape that is parallel to the XY plane. The valve member **217D** has a thickness between 2 μm and 200 μm , for example.

In this example, the valve member **217D** is in a rectangular shape. The valve member **217D** may be in any shape other than the rectangular shape (e.g., circular, oval, square, polygonal, or other shape). In this example, the long sides and the short sides of the valve member **217D** extend along the Y axis and the X axis, respectively.

As illustrated in FIG. **14**, in the X-axis direction, the valve member **217D** extends from the negative direction side of the X axis relative to the valve seat **215**, to the positive direction side of the X axis relative to the valve seat **215**. In the Y-axis direction, the valve member **217D** extends from the negative direction side of the Y axis relative to the valve seat **215**, to the positive direction side of the Y axis relative to the valve seat **215**.

In other words, when the main body **2** is viewed toward the negative direction of the Z axis, the valve member **217D** covers the hole defined by the channel defining part **211**, and the valve seat **215**.

Each volume changing body **218D** is made from material undergoes a volume change responsive to pH. In this example, each volume changing body **218D** is made from material which undergoes a volume reduction (in other words, shrinks) upon contacting a fluid with a pH lower than a predetermined threshold (e.g., pH of 5). Each volume changing body **218D** may be made from material that shrinks upon contacting a fluid with a pH higher than a

predetermined threshold (e.g., pH of 4). In this example, each volume changing body **218D** is made from pH-sensitive gel.

The pH-sensitive gel contains, as the main component, at least one of: anion gel having acidic functional group, such as carboxyl group, in macromolecule chain; cation gel having basic functional group in macromolecule chain; and amphoteric gel having both acidic functional group and basic functional group in macromolecule chain, for example. The pH-sensitive gel is an acrylamide-acrylic acid copolymer, for example.

Each volume changing body **218D** is in a pillar shape extending along the Z axis. In this example, the bottom of each volume changing body **218D** is in a rectangular shape. The bottom of each volume changing body **218D** may be in any shape other than the rectangular shape (e.g., circular, oval, square, polygonal, or other shape).

Each volume changing body **218D** has a length in the Z-axis direction (in other words, the height of the volume changing body **218D**) between 10 μm and 1 mm, for example. In this example, the height of each volume changing body **218D** is greater than the thickness of the valve seat **215**.

In this example, the length of each volume changing body **218D** in the Z-axis direction becomes equal to or smaller than the thickness of the valve seat **215** once it has been shrunken completely.

The end face of each volume changing body **218D** on the negative direction side of the Z axis is secured to end face of the surfaces of the main body **2** on the positive direction side of the Z axis. The end face of each volume changing body **218D** on the positive direction side of the Z axis is secured to the end face of the surfaces of the valve member **217D** on the negative direction side of the Z axis.

As illustrated in FIG. **14**, each volume changing body **218D** is disposed between the outer edge of the valve seat **215** and the outer edge of the valve member **217D** on the XY plane. In this example, the four volume changing bodies **218D** are disposed at the respective four corners of the valve member **217D**, in the outer periphery of the valve seat **215**. In other words, the four volume changing bodies **218D** are separated from each other.

In the manner as described above, the valve member **217D** is supported by the main body **2**, in a state that contacting the volume changing bodies **218D**.

As illustrated in FIG. **15**, when the volume changing bodies **218D** shrink, the volume changing bodies **218D** pull the valve member **217D** in the negative direction of the Z axis, thereby causing the valve member **217D** to contact the valve seat **215**. In this example, the valve member **217D** is pressed against the valve seat **215**. As a result, the valve member **217D** closes the channel communicating between the first space SP1 and the outside of the main body **2**.

In this example, each volume changing body **218D** is configured such that that volume changing body **218D** completely shrinks once a fluid has been introduced to the first space SP1 through the hole defined by the channel defining part **211**, when the pH external to the first space SP1 is lower than the above-described threshold.

In this example, the valve seat **215**, the valve member **217D**, and the volume changing bodies **218D** correspond to a valve that closes the channel communicating between the first space SP1 and the outside of the main body **2** responsive to pH.

The volume changing bodies **218D** may have positions and sizes different from the position and the size illustrated in FIG. **14**. Each volume changing body **218D** may be

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located in predetermined regions of the outer periphery of the valve seat **215**, for example.

The number of the volume changing bodies **218D** may be any number other than four.

In the electronic device **1** of the fourth embodiment, each volume changing body **218D** completely shrinks once the gastric fluid has been introduced to the first space **SP1**. This causes the volume changing bodies **218D** to pull the valve member **217D** in the negative direction of the **Z** axis, and thus the valve member **217D** is pressed against the valve seat **215**. As a result, the valve member **217D** closes the channel communicating between the first space **SP1** and the outside of the main body **2**.

This can prevent any matters other than the gastric fluid (e.g., fluid with pH different from that of gastric fluid, solid matter, or the like) from entering the first space **SP1**. As a result, a decline in the power output can be suppressed.

As set forth above, the electronic device **1** of the fourth embodiment operates similarly to the electronic device **1** of the first embodiment, except for the difference in the valve mechanisms. Accordingly, effects and advantages similar to those of the electronic device **1** of the first embodiment are also achieved by the electronic device **1** of the fourth embodiment.

Furthermore, in the electronic device **1** of the fourth embodiment, the valve includes the valve seat **215**, the volume changing bodies **218D** that undergo volume changes responsive to pH, and the valve member **217D** that is supported by the main body **2** with contacting the volume changing bodies **218D**, and closes the channel by contacting the valve seat **215** in response to the change in the volumes of the volume changing bodies **218D**.

In accordance with the above configuration, the volume changing bodies **218D** undergo volume changes in response to the change in pH. This causes the valve member **217D** to contact the valve seat **215**. As a result, the channel communicating between the first space **SP1** and the outside of the main body **2** is closed.

At least a part of the main body **2** may be made from any of optically transmissive material such that the volume changing bodies **218D** are irradiated with light through at least that part of the main body **2**. The optically transmissive material is glass, for example. In this case, a member made from glass and a member made from silicon (Si) may be bonded with anodic bonding.

In accordance with the above configuration, the volume changing bodies **218D** can be formed by irradiating with light through the part of the main body **2**, which is made from the optically transmissive material. This facilitates manufacturing of the electronic device **1** having the volume changing bodies **218D** disposed therein.

Fifth Embodiment

Next, an electronic device of a fifth embodiment will be described. The electronic device of the fifth embodiment is different from the electronic device of the first embodiment in terms of the main body and the valve member. Descriptions will be given focusing on that difference. In the descriptions of the fifth embodiment, elements denoted by like reference symbols denote the same or substantially similar elements used in the first embodiment.

Referring to FIG. 16, the electronic device **1E** of the fifth embodiment includes a main body **2E** in place of the main body **2** of the first embodiment. In FIG. 16 and FIGS. 17-19 described later, illustration of the film **3** is omitted.

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In this example, the main body **2E** is made from silicon (Si). At least a part of the main body **2E** may be made from glass. In this example, the main body **2E** includes a first structure **2E1**, a second structure **2E2**, a third structure **2E3**, and a fourth structure **2E4**.

Each structure **2E1-2E4** is in a pillar shape extending along the **Z** axis. In this example, the bottom of each structure **2E1-2E4** is in a square shape. The bottom of each structure **2E1-2E4** may be in any shape other than the square shape (e.g., circular, oval, rectangular, polygonal, or any other shape).

The bottoms of the second structure **2E2**, the third structure **2E3**, and the fourth structure **2E4** are in the same shape. The outer edge of the bottom of the first structure **2E1** is located inside the outer edge of the bottom of the second structure **2E2**. The central axes of the four structures **2E1-2E4** coincide with each other.

The first structure **2E1**, the second structure **2E2**, the third structure **2E3**, and the fourth structure **2E4** are stacked. The end face of the first structure **2E1** on the negative direction side of the **Z** axis contacts the end face of the second structure **2E2** on the positive direction side of the **Z** axis. The end face of the second structure **2E2** on the negative direction side of the **Z** axis contacts the end face of the third structure **2E3** on the positive direction side of the **Z** axis. The end face of the third structure **2E3** on the negative direction side of the **Z** axis contacts the end face of the fourth structure **2E4** on the positive direction side of the **Z** axis.

The first structure **2E1** includes a recess **21E1**. The recess **21E1** defines a space adjoining the second structure **2E2** on the end face of the first structure **2E1** on the negative direction side of the **Z** axis. In other words, the recess **21E1** opens at the end face of the first structure **2E1** on the negative direction side of the **Z** axis.

The space defined by the recess **21E1** is in a pillar shape extending along the **Z** axis. In this example, the bottom of the space defined by the recess **21E1** is in a square shape. The bottom of the space defined by the recess **21E1** may be in any shape other than the square shape (e.g., circular, oval, rectangular, polygonal, or any other shape).

The second structure **2E2** includes a through-hole part **21E2**. The through-hole part **21E2** defines a hole passing through the second structure **2E2** in the **Z**-axis direction.

The hole defined by the through-hole part **21E2** is in a pillar shape extending along the **Z** axis. In this example, the bottom of the hole defined by the through-hole part **21E2** is in a square shape. The bottom of the hole defined by the through-hole part **21E2** may be in any shape other than the square shape (e.g., circular, oval, rectangular, polygonal, or any other shape).

In this example, the bottom of the hole defined by the through-hole part **21E2** is in the same shape as that of the bottom of the space defined by the recess **21E1**. In this example, the central axis of the hole defined by the through-hole part **21E2** coincides with the central axis of the space defined by the recess **21E1**.

The third structure **2E3** includes a recess **21E3**. The recess **21E3** defines a space adjoining the second structure **2E2** on the end face of the third structure **2E3** on the positive direction side of the **Z** axis. In other words, the recess **21E3** opens at the end face of the third structure **2E3** on the positive direction side of the **Z** axis. The recess **21E3** is located at the end part of the third structure **2E3** on the **XY** plane (in other words, the part other than the center part of the third structure **2E3** on the **XY** plane).

The space defined by the recess **21E3** is in a pillar shape extending along the **Z** axis. In this example, the bottom of

the space defined by the recess **21E3** is in a square shape having an absence in a rectangular shape at the center part of the square shape. The bottom of the space defined by the recess **21E3** may be in any shape other than the square shape (e.g., circular, oval, rectangular, polygonal, or any other shape).

In this example, the central axis of the space defined by the recess **21E3** coincides with the central axis of the hole defined by the through-hole part **21E2**.

The hole defined by the through-hole part **21E2** contacts each of the space defined by the recess **21E1** and the space defined by the recess **21E3**. In this example, the space defined by the recess **21E1**, the hole defined by the through-hole part **21E2**, and the space defined by the recess **21E3** constitute the first space **SP1** defined inside the main body **2E**.

The fourth structure **2E4** includes a recess **22E**. The recess **22E** defines a space adjoining the third structure **2E3** on the end face of the fourth structure **2E4** on the positive direction side of the *Z* axis. In other words, the recess **22E** opens at the end face of the fourth structure **2E4** on the positive direction side of the *Z* axis. The recess **22E** is located at the end part of the fourth structure **2E4** on the *XY* plane (in other words, the part other than the center part of the fourth structure **2E4** on the *XY* plane).

The space defined by the recess **22E** adjoins the end face of the third structure **2E3** on the negative direction side of the *Z* axis. In this example, the end face of the third structure **2E3** on the negative direction side of the *Z* axis, and the space defined by the recess **22E** constitute the second space **SP2** defined inside the main body **2E**.

In this example, the first structure **2E1**, the second structure **2E2**, and the third structure **2E3** constitute a first layer. Additionally, in this example, the fourth structure **2E4** constitute a second layer different from the first layer.

The electronic device **1E** may include a retaining member made from porous material in the first space **SP1**. In this case, the porous material is preferably hydrophilic.

As illustrated in FIGS. **16** and **17**, the third structure **2E3** includes a first channel defining part **211E1**. FIG. **17** illustrates the cross-section of the electronic device **1E** on the plane passing Line XVII-XVII in FIG. **16**. The fourth structure **2E4** includes a second channel defining part **211E2**. The second structure **2E2** includes multiple (16 in this example) through-hole parts **212E**.

The first channel defining part **211E1** defines a hole that passes through the center part of the third structure **2E3** on the *XY* plane in the *Z*-axis direction, and is shaped to be a part of a cone extending along the *Z* axis.

In this example, the bottom of the hole defined by the first channel defining part **211E1** is in a rectangular shape. The bottom of the hole defined by the first channel defining part **211E1** may be in any shape other than the rectangular shape (e.g., circular, oval, square, polygonal, or other shape). The hole defined by the first channel defining part **211E1** may be in a pillar shape.

The long sides of the bottom of the hole defined by the first channel defining part **211E1** have a length between 200 μm and 20 mm, for example. The short sides of the bottom of the hole defined by the first channel defining part **211E1** have a length between 100 μm and 10 mm, for example.

The long sides and the short sides of the bottom of the hole defined by the first channel defining part **211E1** extend along the *Y* axis and the *X* axis, respectively.

The second channel defining part **211E2** defines a hole that passes through the center part of the fourth structure **2E4**

on the *XY* plane in the *Z*-axis direction, and is in a pillar shape extending along the *Z* axis.

In this example, the bottom of the hole defined by the second channel defining part **211E2** is in a rectangular shape. The bottom of the hole defined by the second channel defining part **211E2** may be in any shape other than the rectangular shape (e.g., circular, oval, square, polygonal, or other shape). The hole defined by the second channel defining part **211E2** may be shaped to be a part of a cone.

In this example, the bottom of the hole defined by the second channel defining part **211E2** is in the same shape as that of the bottom of the hole defined by the first channel defining part **211E1** on the negative direction side of the *Z* axis. The central axis of the hole defined by the second channel defining part **211E2** coincides with the central axis of the hole defined by the first channel defining part **211E1**.

In this example, the hole defined by the first channel defining part **211E1** and the hole defined by the second channel defining part **211E2** communicate between the first space **SP1** and the outside of the main body **2E**. In this example, the hole defined by the first channel defining part **211E1** and the hole defined by the second channel defining part **211E2** correspond to a channel.

In this example, the first channel defining part **211E1**, the second channel defining part **211E2**, the recess **21E1**, the through-hole part **21E2**, and the recess **21E3** are coated with hydrophilic films. The hydrophilic films are made from silicon dioxide, for example.

As illustrated in FIGS. **16** and **18**, each through-hole part **212E** defines a hole that passes through the second structure **2E2** in the *Z*-axis direction, and is in a pillar shape extending along the *Z* axis. FIG. **18** is a diagram of the second structure **2E2** when viewed toward the negative direction of the *Z* axis.

In this example, the bottom of the hole defined by each through-hole part **212E** is in a circular shape. The bottom of the hole defined by each through-hole part **212E** may be in any shape other than the circular shape (e.g., oval, square, rectangular, polygonal, or other shape). The hole defined by each through-hole part **212E** may be shaped to be a part of a cone.

In this example, the area of the bottom of the hole defined by each through-hole part **212E** is smaller than the area of the bottom of the hole defined by the first channel defining part **211E1**. The bottom of the hole defined by each through-hole part **212E** has a diameter between 2 μm and 200 μm , for example.

As illustrated in FIG. **16**, the through-hole parts **212E** are located outside the outer edge of the first structure **2E1** on the *XY* plane. In this example, as illustrated in FIG. **18**, the through-hole parts **212E** are arranged in both ends of the second structure **2E2** in the *X*-axis direction. The multiple through-hole parts **212E** are spaced apart at regular intervals along the *Y* axis.

In the manner described above, the hole defined by each through-hole part **212E** communicates between the first space **SP1** and the outside of the main body **2E**.

The number of the through-hole parts **212E** may be any number other than eight.

In this example, each through-hole part **212E** is covered with a water-repellent film. The water-repellent film is made from fluorocarbon resin (e.g., resin containing polytetrafluoroethylene as the main component), for example.

Further, the electronic device **1E** includes a first electrode **213E**, a second electrode **214E**, a valve seat **215E**, multiple (two in this example) supports **216E**, and a valve member **217E**, in place of the first electrode **213**, the second electrode

214, the valve seat **215**, the multiple supports **216**, and the valve member **217** of the first embodiment.

In this example, the main body **2E**, the film **3**, the first electrode **213E**, the second electrode **214E**, the valve seat **215E**, the multiple supports **216E**, and the valve member **217E** of the electronic device **1E** constitute a battery. In this example, the first electrode **213E** and the second electrode **214E** may also be referred to as the pair of electrodes.

In this example, the first electrode **213E** is made from magnesium. The first electrode **213E** may be made from any material other than magnesium (e.g., zinc, alloy, or the like). Alternatively, the first electrode **213E** may be a film stack where multiple layers respectively made from different materials are stacked.

The first electrode **213E** is in a planer shape that is parallel to the XY plane. The first electrode **213E** has a thickness between 100 nm and 2 mm, for example. In this example, the first electrode **213E** is in a rectangular shape of which the long sides and the short sides extend along the Y axis and the X axis, respectively. The first electrode **213E** has a recess on the long side on the positive direction side of the X axis. The first electrode **213E** may be in any shape other than the rectangular shape (e.g., circular, oval, square, polygonal, or other shape).

The first electrode **213E** contacts the end face of the recess **21E3** on the negative direction side of the Z axis.

In this example, the area of the first electrode **213E** is slightly smaller than the half of the area of the end face of the recess **21E3** on the negative direction side of the Z axis.

In this example, the second electrode **214E** is made from platinum. The second electrode **214E** may be made from any material other than platinum (e.g., copper chloride (CuCl), silver chloride (AgCl), alloy, or the like). Alternatively, the second electrode **214E** may be a film stack where multiple layers respectively made from different materials are stacked.

The second electrode **214E** is in a planer shape that is parallel to the XY plane. The second electrode **214E** has a thickness between 10 nm and 2 mm, for example. In this example, the second electrode **214E** is in a rectangular shape of which the long sides and the short sides extend along the Y axis and the X axis, respectively. The second electrode **214E** has a recess on the long side on the negative direction side of the X axis. The second electrode **214E** may be in any shape other than the rectangular shape (e.g., circular, oval, square, polygonal, or other shape).

The second electrode **214E** contacts the end face of the recess **21E3** on the negative direction side of the Z axis.

In this example, the area of the second electrode **214E** is slightly smaller than the half of the area of the end face of the recess **21E3** on the negative direction side of the Z axis.

In this example, the first electrode **213E** is located on the negative direction side of the X axis relative to the center in the X-axis direction, in the end face of the recess **21E3** on the negative direction side of the Z axis. In this example, the second electrode **214E** is located on the positive direction side of the X axis relative to the center in the X-axis direction, in the end face of the recess **21E3** on the negative direction side of the Z axis. In other words, the first electrode **213E** and the second electrode **214E** are separated from each other.

In this example, the materials for the first electrode **213E** and the second electrode **214E** are selected such that electric power is generated by a gastric fluid functioning as an electrolyte once the gastric fluid has been introduced to the first space **SP1**.

In this example, the valve seat **215E** is made from metal. The valve seat **215E** may be made from material other than metal (e.g., resin containing polyimide as a main component and the like).

The valve seat **215E** is in a planer shape that is parallel to the XY plane. The valve seat **215E** has a thickness between 10 nm and 10 μm, for example. The valve seat **215E** contacts the end face of the surfaces of the third structure **2E3** on the positive direction side of the Z axis.

The valve seat **215E** has a predetermined width, and extends along the edge of the first channel defining part **211E1** on the positive direction side of the Z axis. The edge part of the first channel defining part **211E1** on the positive direction side of the Z axis may also be referred to as the outer edge of the end face of the hole defined by the first channel defining part **211E1** on the positive direction side of the Z axis. The edge of the first channel defining part **211E1** on the positive direction side of the Z axis may also be referred to as the outer edge of the opening of the hole defined by the first channel defining part **211E1**, in the end face of the surfaces of the third structure **2E3** on the positive direction side of the Z axis.

In other words, the shape of the valve seat **215E** on the XY plane coincides with the shape of the end face of the hole defined by the first channel defining part **211E1** on the positive direction side of the Z axis, and has a hole passing through in the Z-axis direction.

As illustrated in FIG. 18, the valve member **217E** extends from the end face of the through-hole part **21E2** on the negative direction side of the X axis, to the end face of the through-hole part **21E2** on the positive direction side of the X axis. The length of the valve member **217E** in the Y-axis direction is smaller than the length in the Y-axis direction of the end face of the through-hole part **21E2** in the X-axis direction, and is longer than the length in the Y-axis direction of the end face of the hole defined by the first channel defining part **211E1** on the positive direction side of the Z axis.

As illustrated in FIGS. 16, 18, and 19, the valve member **217E** includes a base **217E1** and multiple (two in this example) arms **217E2**. FIG. 19 is a cross-sectional view of the electronic device **1E** on the plane passing Line XVI-XVI in FIG. 18, once the supports **216E** have been dissolved.

The base **217E1** constitutes the center part of the valve member **217E** in the X-axis direction. The length of the base **217E1** in the Z-axis direction (in other words, thickness of the base **217E1**) is equal to the length of the second structure **2E2** in the Z-axis direction (in other words, thickness of the second structure **2E2**). The length of the base **217E1** in the X-axis direction is slightly longer than the length in the X-axis direction of the end face of the hole defined by the first channel defining part **211E1** on the positive direction side of the Z axis.

In other words, when the second structure **2E2** is viewed toward the negative direction of the Z axis, the base **217E1** of the valve member **217E** covers the end face of the hole defined by the first channel defining part **211E1** on the positive direction side of the Z axis, and also covers at least a part of the valve seat **215E**.

The two arms **217E2** constitute both of the end parts of the valve member **217E** in the X-axis direction (in other words, the parts of the valve member **217E** other than the base **217E1**), respectively. In other words, the two arms **217E2** support the base **217E1**.

The length of each arm **217E2** in the Z-axis direction (in other words, thickness of the arm **217E2**) is smaller than the thickness of the second structure **2E2**. Each arm **217E2**

constitutes a part of the end face of the second structure 2E2 on the positive direction side of the Z axis.

As illustrated in FIG. 19, each arm 217E2 is in a planer shape that is parallel to the XY plane while not being elastically deformed.

Each support 216E is made from material that is to be dissolved responsive to pH. In this example, each support 216E is made from material that is to be dissolved upon contacting a fluid with a pH lower than a predetermined threshold (e.g., pH of 5). Each support 216E is made from gastrosoluble material, for example. Each support 216E may be made from material that is dissolved upon contacting a fluid with a pH higher than a predetermined threshold (e.g., pH of 4). In this case, each support 216E may be made from enteric material, for example.

Each support 216E is in a planer shape. Each support 216E has a thickness between 10 nm and 200 μm, for example.

As illustrated in FIGS. 16 and 18, each support 216E is secured to the valve member 217E, with the entire end face of the surfaces of that support 216E on the negative direction side of the Z axis contacting the end face of the surfaces of the valve member 217E on the positive direction side of the Z axis. In this example, the two supports 216E are secured to the respective two arms 217E2.

In the X-axis direction, each support 216E extends from the vicinity of the edge of the arms 217E2 on the negative direction side of the X axis, to the vicinity of the edge of the arms 217E2 on the positive direction side of the X axis. In the Y-axis direction, each support 216E extends from the edge of the valve member 217E on the negative direction side of the Y axis, to the edge of the valve member 217E on the positive direction side of the Y axis.

As illustrated in FIG. 16, the support 216E on the negative direction side of the X axis of the two supports 216E is in a curved state such that a portion of the support 216E is displaced further to the positive direction side of the Z axis as the portion approaches, in the X-axis direction, the end of the support 216E on the positive direction side of the X axis. The support 216E on the positive direction side of the X axis of the two supports 216E is in a curved state such that a portion of the support 216E is displaced further to the positive direction side of the Z axis as the portion approaches, in the X-axis direction, the end of the support 216E on the negative direction side of the X axis.

In other words, each support 216E is in a curved state such that a portion of the support 216E is displaced further to the positive direction side of the Z axis as the portion approaches, in the X-axis direction, the center part of the valve member 217E in the X-axis direction (in other words, the base 217E1).

As a result, the valve member 217E is supported by each support 216E, with being curved by an elastic deformation, such that a portion of the valve member 217E is displaced further to the positive direction side of the Z axis as the portion approaches, in the X-axis direction, the center part of the valve member 217E in the X-axis direction.

In other words, as illustrated in FIG. 16, the arms 217E2 undergo the resiliency F4 generated against the elastic deformation. In this example, the resiliency F4 can be interpreted as the force to restore the arms 217E2 to its unbent state (in other words, the arms 217E2 to be parallel to the XY plane). In this example, the resiliency F4 can also be interpreted as the force to displace the center part of the valve member 217E (in other words, the base 217E1) to the negative direction of the Z axis.

In the manner as described above, the base 217E1 of the valve member 217E is biased toward the valve seat 215E, and is supported by the supports 216E at the location distant from the valve seat 215E.

As illustrated in FIG. 19, once the supports 216E have been dissolved, the arms 217E2 is restored to be parallel to the XY plane by the resiliency F4. Thus causes the base 217E1 of the valve member 217E to contact the valve seat 215E. In this example, the base 217E1 of the valve member 217E is pressed against the valve seat 215E. As a result, the valve member 217E closes the channel communicating between the first space SP1 and the outside of the main body 2E.

The supports 216E may have positions and sizes different from the positions and the sizes illustrated in FIG. 18. The number of the supports 216E may be any number other than two.

In this example, each support 216E is configured such that each support 216E are dissolved completely, once a fluid has been introduced to the first space SP1 through the hole defined by the first channel defining part 211E1 and through the hole defined by the second channel defining part 211E2, when the pH external to the first space SP1 is lower than the above-described threshold.

Furthermore, the electronic device 1E includes the first through-hole part 221E, the second through-hole part 222E, the first terminal 223E, the second terminal 224E, the first conductor 225E, the second conductor 226E, and the circuit 227E that are configured similarly to the first through-hole part 221, the second through-hole part 222, the first terminal 223, the second terminal 224, the first conductor 225, the second conductor 226, and the circuit 227 of the first embodiment.

The electronic device 1E of the fifth embodiment operates in the similar manner to the electronic device 1 of the first embodiment. Accordingly, effects and advantages similar to those of the electronic device 1 of the first embodiment are also achieved by the electronic device 1E of the fifth embodiment.

Sixth Embodiment

Next, an electronic device of the sixth embodiment will be described. The electronic device of the sixth embodiment is different from the electronic device of the fifth embodiment in that volume changing bodies that undergo volume changes responsive to pH are used in place of the supports that are to be dissolved responsive to pH. Descriptions will be given focusing on that difference. In the descriptions of the sixth embodiment, elements denoted by like reference symbols denote the same or substantially similar elements used in the fifth embodiment.

Referring to FIGS. 20-22, the electronic device 1E of the sixth embodiment includes a valve member 217F and a volume changing body 218F, in place of the multiple supports 216E and the valve member 217E of the fifth embodiment.

FIG. 20 is a cross-sectional view of the electronic device 1E on the plane passing Line XX-XX in FIG. 21. FIG. 21 is a diagram of the second structure 2E2 when viewed toward negative direction of the Z axis. FIG. 22 is a cross-sectional view of the electronic device 1E on the plane passing Line XX-XX in FIG. 21, once the volume changing body 218F has expanded.

In this example, the valve seat 215E is on the negative direction side of the Z axis, relative to the end face of the third structure 2E3 on the positive direction side of the Z

axis (in other words, the end face of the second structure 2E2 on the negative direction side of the Z axis). Accordingly, in this example, the end face of the hole defined by the first channel defining part 211E1 on the positive direction side of the Z axis is also on the negative direction side of the Z axis, relative to the end face of the third structure 2E3 on the positive direction side of the Z axis.

As illustrated in FIG. 21, the valve member 217F extends from the end face of the through-hole part 21E2 on the negative direction side of the X axis, to the end face of the through-hole part 21E2 on the positive direction side of the X axis. The length of the valve member 217F in the Y-axis direction is smaller than the length in the Y-axis direction of the end face of the through-hole part 21E2 in the X-axis direction, and is longer than the length in the Y-axis direction of the end face of the hole defined by the first channel defining part 211E1 on the positive direction side of the Z axis.

As illustrated in FIGS. 20 and 21, the valve member 217F includes a base 217F1 and multiple (two in this example) arms 217F2.

The base 217F1 constitutes the center part in the X-axis direction of the valve member 217F. The length of the base 217F1 in the Z-axis direction (in other words, the thickness of the base 217F1) is equal to the length of the second structure 2E2 in the Z-axis direction (in other words, the thickness of the second structure 2E2). The length of the base 217F1 in the X-axis direction is slightly longer than the length in the X-axis direction of the end face of the hole defined by the first channel defining part 211E1 on the positive direction side of the Z axis.

In other words, when the second structure 2E2 is viewed toward the negative direction of the Z axis, the base 217F1 of the valve member 217F covers the end face of the hole defined by the first channel defining part 211E1 on the positive direction side of the Z axis, and also covers at least a part of the valve seat 215E.

The two arms 217F2 constitute both of the end parts of the valve member 217F in the X-axis direction (in other words, the parts of the valve member 217F other than the base 217F1), respectively. In other words, the two arms 217F2 support the base 217F1.

As illustrated in FIG. 20, the length of each arm 217F2 in the Z-axis direction (in other words, the thickness of the arm 217F2) is smaller than the thickness of the second structure 2E2. The position of each arm 217F2 in the Z-axis direction is at the center part in the Z-axis direction of the second structure 2E2.

Each arm 217F2 is in a planer shape that is parallel to the XY plane in a state that the volume changing body 218F does not expand.

The volume changing body 218F is made from material undergoes a volume change responsive to pH. In this example, the volume changing body 218F is made from material which undergoes a volume increase (in other words, expands) upon contacting a fluid with a pH lower than a predetermined threshold (e.g., pH of 5). The volume changing body 218F may be made from material that expands upon contacting a fluid with a pH higher than a predetermined threshold (e.g., pH of 4). In this example, the volume changing body 218F is made from pH-sensitive gel. In this example, expansion may also be referred to as swelling or inflation.

The pH-sensitive gel contains, as the main component, at least one of: anion gel having acidic functional group, such as carboxyl group, in macromolecule chain; cation gel having basic functional group in macromolecule chain; and

amphoteric gel having both acidic functional group and basic functional group in macromolecule chain, for example. The pH-sensitive gel is an acrylamide-acrylic acid copolymer, for example.

The volume changing body 218F is in a pillar shape extending along the Z axis. In this example, the bottom of the volume changing body 218F is in a rectangular shape. The bottom of the volume changing body 218F may be in any shape other than the rectangular shape (e.g., circular, oval, square, polygonal, or other shape).

In this example, the length of the volume changing body 218F in the Z-axis direction (in other words, the height of the volume changing body 218F) is equal to the distance between the end face of the recess 21E1 on the positive direction side of the Z axis and the end face of the second structure 2E2 on the positive direction side of the Z axis (in other words, a first distance).

In this example, the length of the volume changing body 218F in the Z-axis direction after the volume changing body 218F has expanded completely is equal to or greater than the sum of the first distance and a second distance. The second distance is the distance between the end face of the second structure 2E2 on the negative direction side of the Z axis and the end face of the valve seat 215E on the positive direction side of the Z axis.

The end face of the volume changing body 218F on the negative direction side of the Z axis is secured to the end face of the surfaces of the base 217F1 on the positive direction side of the Z axis. The end face of the volume changing body 218F on the positive direction side of the Z axis is secured to the end face of the recess 21E1 on the positive direction side of the Z axis.

As illustrated in FIG. 21, the volume changing body 218F is located inside the outer edge of the base 217F1 on the XY plane.

In the manner as described above, the valve member 217F is supported by the main body 2E with contacting the volume changing body 218F.

As illustrated in FIG. 22, when the volume changing body 218F expands, the volume changing body 218F presses the base 217F1 toward the negative direction of the Z axis, thereby causing the base 217F1 of the valve member 217F to contact the valve seat 215E. In this example, the base 217F1 of the valve member 217F is pressed against the valve seat 215E. As a result, the valve member 217F closes the channel communicating between the first space SP1 and the outside of the main body 2E.

In this example, the volume changing body 218F is configured such that the volume changing body 218F expands completely once a fluid has been introduced to the first space SP1 through the hole defined by the first channel defining part 211E1 and through the hole defined by the second channel defining part 211E2, when the pH external to the first space SP1 is lower than the above-described threshold.

In this example, the valve seat 215E, the valve member 217F and the volume changing body 218F correspond to a valve that closes the channel communicating between the first space SP1 and the outside of the main body 2E, responsive to pH.

The volume changing body 218F may have a position and a size different from the position and the size illustrated in FIG. 21. The number of the volume changing body 218F may be two or greater.

In the electronic device 1E of the sixth embodiment, the volume changing body 218F expands completely once the gastric fluid has been introduced to the first space SP1.

Accordingly, the volume changing body **218F** presses the base **217F1** toward the negative direction of the Z axis, thereby causing the base **217F1** of the valve member **217F** to press the valve seat **215E**. As a result, the valve member **217F** closes the channel communicating between the first space **SP1** and the outside of the main body **2E**.

This can prevent any matter other than the gastric fluid (e.g., fluid with pH different from that of gastric fluid, solid matter, or the like) from entering the first space **SP1**. As a result, a decline in the power output can be suppressed.

As set forth above, the electronic device **1E** of the sixth embodiment operates similarly to the electronic device **1E** of the fifth embodiment, except for the difference in the valve mechanisms. Accordingly, effects and advantages similar to those of the electronic device **1E** of the fifth embodiment are also achieved by the electronic device **1E** of the sixth embodiment.

Furthermore, in the electronic device **1E** of the sixth embodiment, the valve includes the valve seat **215E**, the volume changing body **218F** that undergoes a volume change responsive to pH, and the valve member **217F** that is supported by the main body **2E** with contacting the volume changing body **218F**, and closes the channel by contacting the valve seat **215E** upon a change in the volume of the volume changing body **218F**.

In accordance with the above configuration, the volume changing body **218F** undergoes a volume change in response to the change in pH. This causes the valve member **217F** to contact the valve seat **215E**. As a result, the channel communicating between the first space **SP1** and the outside of the main body **2E** is closed.

At least a part of the main body **2E** may be made from any of optically transmissive materials such that the volume changing body **218F** is irradiated with light through at least that part of the main body **2E**. The first structure **2E1** may be made from optically transmissive material, for example. The optically transmissive material is glass, for example. In this case, a member made from glass and a member made from silicon (Si) may be bonded with anodic bonding.

In accordance with the above configuration, the volume changing body **218F** can be formed by irradiating with light through the part of the main body **2E**, which is made from the optically transmissive material. This facilitates manufacturing of the electronic device **1E** having the volume changing body **218F** disposed therein.

Seventh Embodiment

Next, an electronic device of a seventh embodiment will be described. The electronic device of the seventh embodiment is different from the electronic device of the fifth embodiment in that volume changing bodies that undergo volume changes responsive to pH are used, in place of the supports that are to be dissolved responsive to pH. Descriptions will be given focusing on that difference. In the descriptions of the seventh embodiment, elements denoted by like reference symbols denote the same or substantially similar elements used in the fifth embodiment.

Referring to FIGS. **23-25**, the electronic device **1E** of the seventh embodiment includes a valve member **217G** and multiple (two in this example) volume changing bodies **218G**, in place of the multiple supports **216E** and the valve member **217E** of the fifth embodiment.

FIG. **23** is a cross-sectional view of the electronic device **1E** on the plane passing Line XXIII-XXIII in FIG. **24**. FIG. **24** is a diagram of the second structure **2E2** when viewed toward the negative direction of the Z axis. FIG. **25** is a

cross-sectional view of the electronic device **1E** once the volume changing bodies **218G** have expanded, on the plane passing Line XXIII-XXIII in FIG. **24**.

As illustrated in FIG. **24**, the valve member **217G** extends, from the end face of the through-hole part **21E2** on the negative direction side of the X axis, to the end face of the through-hole part **21E2** on the positive direction side of the X axis. The length in the Y-axis direction of the valve member **217G** is smaller than the length in the Y-axis direction of the end face of the through-hole part **21E2** in the X-axis direction, and is longer than the length in the Y-axis direction of the end face of the hole defined by the first channel defining part **211E1** on the positive direction side of the Z axis.

As illustrated in FIGS. **23** and **24**, the valve member **217G** includes a base **217G1** and multiple (two in this example) arms **217G2**.

The base **217G1** constitutes the center part in the X-axis direction of the valve member **217G**. The length of the base **217G1** in the Z-axis direction (in other words, the thickness of the base **217G1**) is smaller than the length of the second structure **2E2** in the Z-axis direction (in other words, the thickness of the second structure **2E2**). In this example, the thickness of the base **217G1** is substantially the half of the thickness of the second structure **2E2**.

The length of the base **217G1** in the X-axis direction is slightly longer than the length in the X-axis direction of the end face of the hole defined by the first channel defining part **211E1** on the positive direction side of the Z axis.

In other words, when the second structure **2E2** is viewed toward the negative direction of the Z axis, the base **217G1** of the valve member **217G** covers the end face of the hole defined by the first channel defining part **211E1** on the positive direction side of the Z axis, and also covers at least a part of the valve seat **215E**.

The base **217G1** constitutes a part of the end face of the second structure **2E2** on the positive direction side of the Z axis.

The two arms **217G2** constitute both of the end parts of the valve member **217G** in the X-axis direction (in other words, the parts of the valve member **217G** other than the base **217G1**), respectively. In other words, the two arms **217G2** support the base **217G1**.

As illustrated in FIG. **23**, the length in the Z-axis direction of each arm **217G2** (in other words, the thickness of the arm **217G2**) is smaller than the length of the base **217G1** in the Z-axis direction (in other words, the thickness of the base **217G1**). Each arm **217G2** constitutes a part of the end face of the second structure **2E2** on the positive direction side of the Z axis.

Each arm **217G2** is in a planer shape that is parallel to the XY plane in a state that the volume changing bodies **218G** do not expand. Accordingly, the end face of the base **217G1** on the negative direction side of the Z axis is away from the valve seat **215E**, in a state that the volume changing bodies **218G** do not expand.

Each volume changing body **218G** is made from material undergoes a volume change responsive to pH. In this example, each volume changing body **218G** is made from material which undergoes a volume increase (in other words, expands) upon contacting a fluid with a pH lower than a predetermined threshold (e.g., pH of 5). Each volume changing body **218G** may be made from material that expands upon contacting a fluid with a pH higher than a predetermined threshold (e.g., pH of 4). In this example, each

volume changing body **218G** is made from pH-sensitive gel. In this example, expansion may also be referred to as swelling or inflation.

The pH-sensitive gel contains, as the main component, at least one of: anion gel having acidic functional group, such as carboxyl group, in macromolecule chain; cation gel having basic functional group in macromolecule chain; and amphoteric gel having both acidic functional group and basic functional group in macromolecule chain, for example. The pH-sensitive gel is an acrylamide-acrylic acid copolymer, for example.

As illustrated in FIGS. **23** and **24**, each volume changing body **218G** is in a planer shape that is parallel to the XY plane. Each volume changing body **218G** is secured to the valve member **217G** such that the entire end face of the surfaces of that volume changing body **218G** on the negative direction side of the Z axis contacts the end face of the surfaces of the valve member **217G** on the positive direction side of the Z axis. In this example, the two volume changing bodies **218G** are secured to the respective two arms **217G2**.

In the X-axis direction, each volume changing body **218G** extends from the vicinity of the edge of the arm **217G2** on the negative direction side of the X axis, to the vicinity of the edge of the arm **217G2** on the positive direction side of the X axis. In the Y-axis direction, each volume changing body **218G** extends from the edge of the valve member **217G** on the negative direction side of the Y axis, to the edge of the valve member **217G** on the positive direction side of the Y axis.

In the manner as described above, the valve member **217G** is supported by the main body **2E** with contacting the volume changing bodies **218G**.

As illustrated in FIG. **25**, volume changing bodies **218G** stretch the respective arms **217G2** in the X-axis direction once the volume changing bodies **218G** have expanded, and hence each arm **217G2** is curved such that a portion of the arm **217G2** is displaced further to the negative direction of the Z axis as the portion approaches, in the X-axis direction, the base **217G1**. This causes the base **217G1** of the valve member **217G** to contact the valve seat **215E**. In this example, the base **217G1** of the valve member **217G** is pressed against the valve seat **215E**. As a result, the valve member **217G** closes the channel communicating between the first space **SP1** and the outside of the main body **2E**.

In this example, the volume changing bodies **218G** is configured such that the volume changing bodies **218G** expand completely once a fluid has been introduced to the first space **SP1** through the hole defined by the first channel defining part **211E1** and through the hole defined by the second channel defining part **211E2**, when the pH external to the first space **SP1** is lower than the above-described threshold.

In this example, the valve seat **215E**, the valve member **217G**, and the volume changing bodies **218G** correspond to a valve that closes the channel communicating between the first space **SP1** and the outside of the main body **2E**, responsive to pH.

The volume changing bodies **218G** may have positions and sizes different from the positions and the sizes illustrated in FIG. **24**. The number of the volume changing bodies **218G** may be two or greater.

In the electronic device **1E** of the seventh embodiment, the volume changing bodies **218G** expand completely once the gastric fluid has been introduced to the first space **SP1**. This causes the arms **217G2** to be curved. This causes the base **217G1** of the valve member **217G** to be pressed against the valve seat **215E**. As a result, the valve member **217G**

closes the channel communicating between the first space **SP1** and the outside of the main body **2E**.

This can prevent any matter other than the gastric fluid (e.g., fluid with pH different from that of gastric fluid, solid matter, or the like) from entering the first space **SP1**. As a result, a decline in the power output can be suppressed.

As set forth above, the electronic device **1E** of the seventh embodiment operates similarly to the electronic device **1E** of the fifth embodiment, except for the difference in the valve mechanisms. Accordingly, effects and advantages similar to those of the electronic device **1E** of the fifth embodiment are also achieved by the electronic device **1E** of the seventh embodiment.

Further, in the electronic device **1E** of the seventh embodiment, the valve includes a valve seat **215E**, volume changing bodies **218G** that undergo volume changes responsive to pH, and a valve member **217G** that is supported by the main body **2E** with contacting the volume changing bodies **218G**, and closes the channel by contacting the valve seat **215E** upon a change in the volume of the volume changing bodies **218G**.

In accordance with the above configuration, the volume changing bodies **218G** undergo volume changes in response to the change in pH. This causes the valve member **217G** to contact the valve seat **215E**. As a result, the channel communicating between the first space **SP1** and the outside of the main body **2E** is closed.

At least a part of the main body **2E** may be made from any of optically transmissive material such that the volume changing bodies **218G** are irradiated with light through at least that part of the main body **2E**. The first structure **2E1** may be made from optically transmissive material, for example. The optically transmissive material is glass, for example. In this case, a member made from glass and a member made from silicon (Si) may be bonded with anodic bonding.

In accordance with the above configuration, the volume changing bodies **218G** can be formed by irradiating with light through the part of the main body **2E**, which is made from the optically transmissive material. This facilitates manufacturing of the electronic device **1E** having the volume changing bodies **218G** disposed therein.

Eighth Embodiment

Next, an electronic device of an eighth embodiment will be described. The electronic device of the eighth embodiment is different from the electronic device of the first embodiment in terms of the valve. Descriptions will be given focusing on that difference. In the descriptions of the eighth embodiment, elements denoted by like reference symbols denote the same or substantially similar elements used in the first embodiment.

Referring to FIGS. **26-28**, the electronic device **1** of the eighth embodiment includes a volume changing body **219H**, in place of the valve seat **215**, the multiple supports **216** and the valve member **217** of the first embodiment.

FIG. **26** is a partial cross-sectional view of the electronic device **1** on the plane passing Line XXVI-XXVI in FIG. **27**, in an enlarged view of the volume changing body **219H**. FIG. **27** is an enlarged view of the area in the vicinity of the volume changing body **219H**, when the main body **2** is viewed toward the negative direction of the Z axis. FIG. **28** is a partial cross-sectional view of the electronic device **1** on the plane passing Line XXVI-XXVI in FIG. **27**, in an enlarged view of the volume changing body **219H** when the volume changing body **219H** expands.

The volume changing body **219H** is made from material undergoes a volume change responsive to pH. In this example, the volume changing body **219H** is made from material which undergoes a volume increase (in other words, expands) upon contacting a fluid with a pH lower than a predetermined threshold (e.g., pH of 5). The volume changing body **219H** may be made from material that expands upon contacting a fluid with a pH higher than a predetermined threshold (e.g., pH of 4). In this example, the volume changing body **219H** is made from pH-sensitive gel. In this example, expansion may also be referred to as swelling or inflation.

The pH-sensitive gel contains, as the main component, at least one of: anion gel having acidic functional group, such as carboxyl group, in macromolecule chain; cation gel having basic functional group in macromolecule chain; and amphoteric gel having both acidic functional group and basic functional group in macromolecule chain, for example. The pH-sensitive gel is an acrylamide-acrylic acid copolymer, for example.

The volume changing body **219H** is in the same shape as that of the hole defined by the channel defining part **211**. The volume changing body **219H** contacts the channel defining part **211**. In this example, the volume changing body **219H** is secured to the channel defining part **211**. As a result, in this example, the volume changing body **219H** is disposed at the channel communicating between the first space **SP1** and the outside of the main body **2**.

The volume changing body **219H** includes a through-hole part **219H1**. The through-hole part **219H1** defines a hole that passes through the volume changing body **219H** in the Z-axis direction, and is in a pillar shape extending along the Z axis. In other words, the hole defined by the through-hole part **219H1** communicates between the first space **SP1** and the outside of the main body **2**.

In this example, the bottom of the hole defined by the through-hole part **219H1** is in a rectangular shape. The bottom of the hole defined by the through-hole part **219H1** may be in any shape other than the rectangular shape (e.g., circular, oval, square, polygonal, or other shape).

The volume changing body **219H** may be provided with multiple through-hole parts **219H1**.

As illustrated in FIG. **28**, once the volume changing body **218H** has expanded, the hole defined by the through-hole part **219H1** is occluded. As a result, the volume changing body **219H** closes the channel communicating between the first space **SP1** and the outside of the main body **2**.

In this example, the volume changing body **219H** is configured such that the volume changing body **219H** expands completely once a fluid has been introduced to the first space **SP1** through the hole defined by the channel defining part **211**, when the pH external to the first space **SP1** is lower than the above-described threshold.

In this example, the volume changing body **219H** corresponds to a valve that closes the channel communicating between the first space **SP1** and the outside of the main body **2** responsive to pH.

In the electronic device **1** of the eighth embodiment, the volume changing body **219H** expands completely once the gastric fluid has been introduced to the first space **SP1**. This causes the hole defined by the through-hole part **219H1** to be occluded. As a result, the volume changing body **219H** closes the channel communicating between the first space **SP1** and the outside of the main body **2**.

This can prevent any matter other than the gastric fluid (e.g., fluid with pH different from that of gastric fluid, solid

matter, or the like) from entering the first space **SP1**. As a result, a decline in the power output can be suppressed.

As set forth above, the electronic device **1** of the eighth embodiment operates similarly to the electronic device **1** of the first embodiment, except for the difference in the valve mechanisms. Accordingly, effects and advantages similar to those of the electronic device **1** of the first embodiment are also achieved by the electronic device **1** of the eighth embodiment.

Further, in the electronic device **1** of the eighth embodiment, the valve includes the volume changing body **219H** that is disposed at the channel communicating between the first space **SP1** and the outside of the main body **2**, and closes the channel by undergoing a volume increase responsive to pH.

In accordance with the above configuration, the volume changing body **219H** undergoes a volume change in response to a change in the pH in the channel. This causes the volume changing body **219H** to occlude the channel. As a result, the channel communicating between the first space **SP1** and the outside of the main body **2** is closed.

The volume changing body **219H** may be made from material which undergoes a volume reduction (in other words, shrinks) upon contacting a fluid with a pH lower than a predetermined threshold (e.g., pH of 5). In this case, preferably, the volume changing body **219H** occludes the channel when the volume changing body **219H** does not shrink, and allows a communication between the first space **SP1** and the outside of the main body **2** once the volume changing body **219H** has shrunken.

At least a part of the main body **2** may be made from any of optically transmissive material such that the volume changing body **219H** is irradiated with light through at least that part of the main body **2**. The optically transmissive material is glass, for example. In this case, a member made from glass and a member made from silicon (Si) may be bonded with anodic bonding.

In accordance with the above configuration, the volume changing body **219H** can be formed by irradiating with light through the part of the main body **2**, which is made from the optically transmissive material. This facilitates manufacturing of the electronic device **1** having the volume changing body **219H** disposed therein.

Ninth Embodiment

Next, an electronic device of a ninth embodiment will be described. The electronic device of the ninth embodiment is different from the electronic device of the first embodiment in terms of the main body and the valve. Descriptions will be given focusing on that difference. In the descriptions of the ninth embodiment, elements denoted by like reference symbols denote the same or substantially similar elements used in the first embodiment.

As illustrated in FIGS. **29-33**, the electronic device **1J** of the ninth embodiment includes a main body **2J**, in place of the main body **2** of the first embodiment. In FIGS. **29-33**, illustration of the film **3** is omitted.

FIG. **30** is a cross-sectional view of the electronic device **1J** on the plane passing Line XXX-XXX in FIG. **29**. FIG. **31** is a partial cross-sectional view of the electronic device **1J** on the plane passing Line XXXI-XXXI in FIG. **29**. FIG. **32** is a partial cross-sectional view of the electronic device **1J** on the plane passing Line XXXII-XXXII in FIG. **29**. FIG. **33** is a partial cross-sectional view of the electronic device **1J** on the plane passing Line XXXIII-XXXIII in FIG. **29**.

In this example, the main body 2J is made from silicon (Si). At least a part of the main body 2J may be made from glass. In this example, as illustrated in FIG. 30, the main body 2J includes a first structure 2J1, a second structure 2J2, and a third structure 2J3.

Each structures 2J1-2J3 is in a pillar shape extending along the Z axis. In this example, the bottom of each structures 2J1-2J3 is in a square shape. The bottom of each structures 2J1-2J3 may be in any shape other than the square shape (e.g., circular, oval, rectangular, polygonal, or any other shape).

The bottoms of the first structure 2J1, the second structure 2J2, and the third structure 2J3 are in the same shape. The central axes of the three structures 2J1-2J3 coincide with each other.

The first structure 2J1, the second structure 2J2, and the third structure 2J3 are stacked. The end face of the first structure 2J1 on the negative direction side of the Z axis contacts the end face of the second structure 2J2 on the positive direction side of the Z axis. The end face of the second structure 2J2 on the negative direction side of the Z axis contacts the end face of the third structure 2J3 on the positive direction side of the Z axis.

The first structure 2J1 includes a first recess 21J, a second recess 211J1, a third recess 211J2, and a through-hole part 211J3.

The first recess 21J, the second recess 211J1, and the third recess 211J2 defines respective spaces adjoining the second structure 2J2, on the end face of the first structure 2J1 on the negative direction side of the Z axis. In other words, the first recess 21J, the second recess 211J1, and the third recess 211J2 open at the end face of the first structure 2J1 on the negative direction side of the Z axis.

The respective spaces defined by the first recess 21J, the second recess 211J1, and the third recess 211J2 adjoin the end face of the second structure 2J2 on the positive direction side of the Z axis.

The space defined by the first recess 21J is in a pillar shape extending along the Z axis. In this example, the bottom of the space defined by the first recess 21J is in a rectangular shape of which the long sides and the short sides extend along the Y axis and the X axis, respectively. The bottom of the space defined by the first recess 21J may be in any shape other than the rectangular shape (e.g., circular, oval, square, polygonal, or other shape).

In this example, the space defined by the first recess 21J extends from the end part of the first structure 2J1 on the negative direction side of the X axis, to the center part in the X-axis direction of the first structure 2J1, in the X-axis direction. In this example, the space defined by the first recess 21J extends from the end part of the first structure 2J1 on the negative direction side of the Y axis, to the end part of the first structure 2J1 on the positive direction side of the Y axis, in the Y-axis direction.

The space defined by the second recess 211J1 is in a pillar shape extending along the Z axis. In this example, the bottom of the space defined by the second recess 211J1 is in a rectangular shape of which the long sides and the short sides extend along the X axis and the Y axis, respectively. The bottom of the space defined by the second recess 211J1 may be in any shape other than the rectangular shape (e.g., circular, oval, square, polygonal, or other shape).

The short sides of the bottom of the space defined by the second recess 211J1 are shorter than the long sides of the bottom of the space defined by the first recess 21J. In this example, the second recess 211J1 is located at center part of the first structure 2J1 in the Y-axis direction.

The end of the second recess 211J1 on the negative direction side of the X axis is connected to the end face of the first recess 21J on the positive direction side of the X axis. In other words, the space defined by the second recess 211J1 continuously communicates with the space defined by the first recess 21J.

The space defined by the third recess 211J2 is in a pillar shape extending along the Z axis. In this example, the bottom of the space defined by the third recess 211J2 is in a rectangular shape of which the long sides and the short sides extend along the Y axis and the X axis, respectively. The bottom of the space defined by the third recess 211J2 may be in any shape other than the rectangular shape (e.g., circular, oval, square, polygonal, or other shape).

The long sides of the bottom of the space defined by the third recess 211J2 are longer than the short sides of the bottom of the space defined by the second recess 211J1. In this example, the long sides of the bottom of the space defined by the third recess 211J2 are shorter than the long sides of the bottom of the space defined by the first recess 21J. In this example, the third recess 211J2 is located at a region which is the center part of the first structure 2J1 in the Y-axis direction, and is the end part of the first structure 2J1 on the positive direction side of the X axis.

The end of the second recess 211J1 on the positive direction side of the X axis is connected to the end face of the third recess 211J2 on the negative direction side of the X axis. In other words, the space defined by the second recess 211J1 continuously communicates with the space defined by the third recess 211J2.

As illustrated in FIGS. 29 and 33, the through-hole part 211J3 defines a hole that passes through the wall of the first structure 2J1 defining the end face of the third recess 211J2 on the positive direction side of the Z axis in the Z-axis direction, and is in a pillar shape extending along the Z axis.

In this example, the bottom of the hole defined by the through-hole part 211J3 is in a rectangular shape. The bottom of the hole defined by the through-hole part 211J3 may be in any shape other than the rectangular shape (e.g., circular, oval, square, polygonal, or other shape). The hole defined by the through-hole part 211J3 may be shaped to be a part of a cone.

In this example, the outer edge of the hole defined by the through-hole part 211J3 on the XY plane is located inside the outer edge of the space defined by the third recess 211J2 on the XY plane.

In this example, the space defined by the end face of the second structure 2J2 on the positive direction side of the Z axis and the first recess 21J constitutes the first space SP1 defined inside the main body 2J.

In this example, the spaces and the holes defined by the end face of the second structure 2J2 on the positive direction side of the Z axis, the second recess 211J1, the third recess 211J2, and the through-hole part 211J3 constitute the channel communicating between the first space SP1 and the outside of the main body 2J.

The third structure 2J3 includes a recess 22J. The recess 22J defines a space adjoining the second structure 2J2 on the end face of the third structure 2J3 on the positive direction side of the Z axis. In other words, the recess 22J opens at the end face of the third structure 2J3 on the positive direction side of the Z axis.

The space defined by the recess 22J adjoins the end face of the second structure 2J2 on the negative direction side of the Z axis. In this example, the space defined by the end face of the second structure 2J2 on the negative direction side of

the Z axis and the recess **22J** constitute the second space **SP2** defined inside the main body **2J**.

In this example, the first structure **2J1** constitutes a first layer. In this example, the third structure **2J3** constitutes a second layer different from the first layer.

The electronic device **1J** may include a retaining member made from porous material in the first space **SP1**. In this case, the porous material is preferably hydrophilic.

In this example, the first recess **21J**, the second recess **211J1**, the third recess **211J2**, and the through-hole part **211J3** are coated with hydrophilic films. The hydrophilic films are made from silicon dioxide, for example.

As illustrated in FIGS. **29** and **31**, the first structure **2J1** includes multiple (eight in this example) through-hole parts **212J**.

Each through-hole part **212J** defines a hole that passes through the wall of the first structure **2J1** defining the end face of the first recess **21J** on the positive direction side of the Z axis in the Z-axis direction, and is in a pillar shape extending along the Z axis.

In this example, the bottom of the hole defined by each through-hole part **212J** is in a circular shape. The bottom of the hole defined by each through-hole part **212J** may be in any shape other than the circular shape (e.g., oval, square, rectangular, polygonal, or other shape). The hole defined by each through-hole part **212J** may be shaped to be a part of a cone.

In this example, the area of the bottom of the hole defined by each through-hole part **212J** is smaller than the area of the bottom of the hole defined by the through-hole part **211J3**. The bottom of the hole defined by each through-hole part **212J** has a diameter between 2 μm and 200 μm , for example.

As illustrated in FIG. **29**, the through-hole parts **212J** are disposed along the end part of the first structure **2J1** on the negative direction side of the X axis. The multiple through-hole parts **212J** are spaced apart at regular intervals along the Y axis.

In the manner as described above, the hole defined by each through-hole part **212J** communicates between the first space **SP1** and the outside of the main body **2J**. The number of the through-hole parts **212J** may be any number other than eight.

In this example, each through-hole part **212J** is covered with a water-repellent film. The water-repellent film is made from fluorocarbon resin (e.g., resin containing polytetrafluoroethylene as the main component), for example.

Further, the electronic device **1J** includes a first electrode **213J**, a second electrode **214J**, multiple (two in this example) volume changing bodies **219J**, in place of the first electrode **213**, the second electrode **214**, the valve seat **215**, the multiple supports **216**, and the valve member **217** of the first embodiment.

In this example, the main body **2J**, the film **3**, the first electrode **213J**, the second electrode **214J**, and the volume changing bodies **219J** of the electronic device **1J** constitute a battery. In this example, the first electrode **213J** and the second electrode **214J** may also be referred to as the pair of electrodes.

In this example, the first electrode **213J** is made from magnesium. The first electrode **213J** may be made from any material other than magnesium (e.g., zinc, alloy, or the like). Alternatively, the first electrode **213J** may be a film stack where multiple layers respectively made from different materials are stacked.

The first electrode **213J** is in a planer shape that is parallel to the XY plane. The first electrode **213J** has a thickness between 100 nm and 2 mm, for example. In this example, the

first electrode **213J** is in a square shape. The first electrode **213J** may be in any shape other than the square shape (e.g., circular, oval, rectangular, polygonal, or any other shape).

The first electrode **213J** contacts the end face of the second structure **2J2** on the positive direction side of the Z axis.

In this example, the area of the first electrode **213J** is slightly smaller than the half of the area of the end face of the first recess **21J** on the positive direction side of the Z axis.

In this example, the second electrode **214J** is made from platinum. The second electrode **214J** may be made from any material other than platinum (e.g., copper chloride (CuCl), silver chloride (AgCl), alloy, or the like). Alternatively, the second electrode **214J** may be a film stack where multiple layers respectively made from different materials are stacked.

The second electrode **214J** is in a planer shape that is parallel to the XY plane. The second electrode **214J** has a thickness between 10 nm and 2 mm, for example. In this example, the second electrode **214J** is in a square shape. The second electrode **214J** may be in any shape other than the square shape (e.g., circular, oval, rectangular, polygonal, or any other shape).

The second electrode **214J** contacts the end face of the second structure **2J2** on the positive direction side of the Z axis.

In this example, the area of the second electrode **214J** is slightly smaller than the half of the area of the end face of the first recess **21J** on the positive direction side of the Z axis.

In this example, the first electrode **213J** is on the positive direction side of the Y axis relative to the center of the first structure **2J1** in the Y-axis direction. In this example, the second electrode **214J** is on the negative direction side of the Y axis relative to the center of the first structure **2J1** in the Y-axis direction. In other words, the first electrode **213J** and the second electrode **214J** are separated from each other.

In this example, the materials of the first electrode **213J** and the second electrode **214J** are selected such that electric power is generated by a gastric fluid functioning as an electrolyte once a gastric fluid has been introduced to the first space **SP1**.

Each volume changing body **219J** is made from material undergoes a volume change responsive to pH. In this example, each volume changing body **219J** is made from material which undergoes a volume increase (in other words, expands) upon contacting a fluid with a pH lower than a predetermined threshold (e.g., pH of 5). Each volume changing body **219J** may be made from material that expands upon contacting a fluid with a pH higher than a predetermined threshold (e.g., pH of 4). In this example, each volume changing body **219J** is made from pH-sensitive gel. In this example, expansion may also be referred to as swelling or inflation.

The pH-sensitive gel contains, as the main component, at least one of: anion gel having acidic functional group, such as carboxyl group, in macromolecule chain; cation gel having basic functional group in macromolecule chain; and amphoteric gel having both acidic functional group and basic functional group in macromolecule chain, for example. The pH-sensitive gel is an acrylamide-acrylic acid copolymer, for example.

As illustrated in FIGS. **29** and **32**, each volume changing body **219J** is in a planer shape parallel to the ZX plane. In this example, each volume changing body **219J** is in a rectangular shape. Each volume changing body **219J** may be

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in any shape other than the rectangular shape (e.g., circular, oval, square, polygonal, or other shape).

In this example, the length of the short sides of each volume changing body 219J is equal to the length in the Z-axis direction of the end face of the second recess 211J1 in the Y-axis direction. In this example, the length of the long sides of each volume changing body 219J is slightly shorter than the length in the X-axis direction of the end face of the second recess 211J1 in the Y-axis direction. The thickness of each volume changing body 219J is shorter than the half of the distance between the end faces of the second recess 211J1 in the Y-axis direction.

The two volume changing bodies 219J contact both of the end faces of the second recess 211J1 in the Y-axis direction, respectively. In this example, the two volume changing bodies 219J are secured to both of the end faces of the second recess 211J1 in the Y-axis direction, respectively. Accordingly, in this example, the volume changing bodies 219J are disposed at the channel communicating between the first space SP1 and the outside of the main body 2J.

In the manner as described above, in this example, the two volume changing bodies 219J are separated from each other. In other words, the space between the two volume changing bodies 219J communicates between the first space SP1 and the outside of the main body 2J.

Once the volume changing bodies 219J have expanded, the two volume changing bodies 219J contact to each other and the space between the two volume changing bodies 219J is occluded. As a result, the two volume changing bodies 219J close the channel communicating between the first space SP1 and the outside of the main body 2J.

In this example, each volume changing body 219J is configured such that the volume changing body 219J expands completely once the fluid has been introduced to the first space SP1 through the channel defined by the second recess 211J1, the third recess 211J2, and the through-hole part 211J3, when the pH external to the first space SP1 is lower than the above-described threshold.

In this example, the volume changing bodies 219J correspond to a valve that closes the channel communicating between the first space SP1 and the outside of the main body 2J, responsive to pH.

The volume changing bodies 219J may have positions and sizes different from the positions and the sizes illustrated in FIG. 29. The number of the volume changing bodies 219J may be any number other than two.

Further, the electronic device 1J includes a first through-hole part 221J, a second through-hole part 222J, a first terminal 223J, a second terminal 224J, a first conductor 225J, a second conductor 226J, and a circuit 227J, which are configured similarly to the first through-hole part 221, the second through-hole part 222, the first terminal 223, the second terminal 224, the first conductor 225, the second conductor 226, and the circuit 227 of the first embodiment.

In the electronic device 1J of the ninth embodiment, the volume changing bodies 219J expand completely once the gastric fluid has been introduced to the first space SP1. This causes the space between the two volume changing bodies 219J to be occluded. As a result, the volume changing bodies 219J closes the channel communicating between the first space SP1 and the outside of the main body 2J.

This can prevent any matter other than the gastric fluid (e.g., fluid with pH different from that of gastric fluid, solid matter, or the like) from entering the first space SP1. As a result, a decline in the power output can be suppressed.

As set forth above, the electronic device 1J of the ninth embodiment operates similarly to the electronic device 1 of

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the first embodiment, except for the difference in the valve mechanisms. Accordingly, effects and advantages similar to those of the electronic device 1 of the first embodiment are also achieved by the electronic device 1J of the ninth embodiment.

Further, in the electronic device 1J of the ninth embodiment, the valve includes the volume changing bodies 219J that are disposed at the channel communicating between the first space SP1 and the outside of the main body 2J, and close the channel by undergoing volume increases responsive to pH.

In accordance with the above configuration, the volume changing bodies 219J undergo volume changes in response to a change in the pH in the channel. This causes the volume changing bodies 219J to occlude the channel. As a result, the channel communicating between the first space SP1 and the outside of the main body 2J is closed.

The volume changing bodies 219J may be made from material which undergoes a volume reduction (in other words, shrinks) upon contacting a fluid with a pH lower than a predetermined threshold (e.g., pH of 5). In this case, preferably, the volume changing bodies 219J occlude the channel when the volume changing bodies 219J do not shrink, and permit to communicate between the first space SP1 and the outside of the main body 2J once the volume changing bodies 219J have shrunken.

At least a part of the main body 2J may be made from any of optically transmissive material such that the volume changing bodies 219J are irradiated with light through the part of the main body 2J. The second structure 2J2 may be made from optically transmissive material, for example. The optically transmissive material is glass, for example. In this case, a member made from glass and a member made from silicon (Si) may be bonded with anodic bonding.

In accordance with the above configuration, the volume changing bodies 219J can be formed by irradiating with light through the part of the main body 2J, which is made from the optically transmissive material. This facilitates manufacturing of the electronic device 1J having the volume changing bodies 219J disposed therein.

First Modification to Ninth Embodiment

Next, an electronic device of a first modification to the ninth embodiment will be described. The electronic device of the first modification to the ninth embodiment is different from the electronic device of the ninth embodiment in terms of the main body and the number of valves. Descriptions will be given focusing on that difference. In the first modification to the ninth embodiment, elements denoted by like reference symbols denote the same or substantially similar elements used in the ninth embodiment.

Referring to FIGS. 34-36, an electronic device 1K of the first modification to the ninth embodiment includes a main body 2K, in place of the main body 2J of the ninth embodiment. In FIGS. 34-36, illustration of the film 3 is omitted.

FIG. 35 is a cross-sectional view of the electronic device 1K on the plane passing Line XXXV-XXXV in FIG. 34. FIG. 36 is a partial cross-sectional view of the electronic device 1K on the plane passing Line XXXVI-XXXVI in FIG. 34.

In this example, the main body 2K is made from silicon (Si). At least a part of the main body 2K may be made from glass. In this example, as illustrated in FIGS. 35 and 36, the main body 2K includes a first structure 2K1 and a second structure 2K2.

Each structure **2K1-2K2** is in a pillar shape extending along the *Z* axis. In this example, the bottom of each structure **2K1-2K2** is in a square shape. The bottom of each structure **2K1-2K2** may be in any shape other than the square shape (e.g., circular, oval, rectangular, polygonal, or any other shape).

The bottoms of the first structure **2K1** and the second structure **2K2** are in the same shape. The central axes of the two structures **2K1-2K2** coincide with each other.

The first structure **2K1** and the second structure **2K2** are stacked. The end face of the first structure **2K1** on the negative direction side of the *Z* axis contacts the end face of the second structure **2K2** on the positive direction side of the *Z* axis.

The first structure **2K1** includes a first recess **21K**, a second recess **211K1**, a third recess **211K2**, a first through-hole part **211K3**, a fourth recess **211K4**, a fifth recess **211K5**, a sixth recess **228K1**, a seventh recess **228K2**, a second through-hole part **228K3**, and a third through-hole part **228K4**.

The recesses **21K**, **211K1**, **211K2**, **211K4**, **211K5**, **228K1**, **228K2** define a space adjoining the second structure **2K2** on the end face of the first structure **2K1** on the negative direction side of the *Z* axis. In other words, the recesses **21K**, **211K1**, **211K2**, **211K4**, **211K5**, **228K1**, **228K2** open at end face of the first structure **2K1** on the negative direction side of the *Z* axis.

The space defined by the recesses **21K**, **211K1**, **211K2**, **211K4**, **211K5**, **228K1**, **228K2** contacts the end face of the second structure **2K2** on the positive direction side of the *Z* axis.

The space defined by the first recess **21K** is in a pillar shape extending along the *Z* axis. In this example, the bottom of the space defined by the first recess **21K** is in a rectangular shape of which the long sides and the short sides extend along the *Y* axis and the *X* axis, respectively. The bottom of the space defined by the first recess **21K** may be in any shape other than the rectangular shape (e.g., circular, oval, square, polygonal, or other shape).

In this example, the position of the space defined by the first recess **21K** on the *XY* plane is the center part of the first structure **2K1** on the *XY* plane.

Each of the spaces defined by the second recess **211K1** and the fourth recess **211K4** is in a pillar shape extending along the *Z* axis. In this example, the bottom of each of the spaces respectively defined by the second recess **211K1** and the fourth recess **211K4** is in a rectangular shape of which the long sides and the short sides extend along the *X* axis and the *Y* axis, respectively. The bottom of each of the spaces respectively defined by the second recess **211K1** and the fourth recess **211K4** may be in any shape other than the rectangular shape (e.g., circular, oval, square, polygonal, or other shape).

The short sides of the bottom of each of the spaces respectively defined by the second recess **211K1** and the fourth recess **211K4** is shorter than the long sides of the bottom of the space defined by the first recess **21K**. In this example, the second recess **211K1** and the fourth recess **211K4** are each located at the center part of the first structure **2K1** in the *Y*-axis direction.

The end of the second recess **211K1** on the negative direction side of the *X* axis is connected to the end face of the first recess **21K** on the positive direction side of the *X* axis. In other words, the space defined by the second recess **211K1** continuously communicates with the space defined by the first recess **21K**.

The end of the fourth recess **211K4** on the positive direction side of the *X* axis is connected to the end face of the first recess **21K** on the negative direction side of the *X* axis. In other words, the space defined by the fourth recess **211K4** continuously communicates with the space defined by the first recess **21K**.

Each of the spaces respectively defined by the third recess **211K2** and the fifth recess **211K5** is in a pillar shape extending along the *Z* axis. In this example, the bottom of each of the spaces respectively defined by the third recess **211K2** and the fifth recess **211K5** is in a rectangular shape of which the long sides and the short sides extend along the *Y* axis and the *X* axis, respectively. The bottom of each of the spaces respectively defined by the third recess **211K2** and the fifth recess **211K5** may be in any shape other than the rectangular shape (e.g., circular, oval, square, polygonal, or other shape).

The long sides of the bottom of each of the spaces respectively defined by the third recess **211K2** and the fifth recess **211K5** is longer than the short sides of the bottom of the space defined by the second recess **211K1** or the fourth recess **211K4**. In this example, the long sides of the bottom of each of the spaces respectively defined by the third recess **211K2** and the fifth recess **211K5** is shorter than the long sides of the bottom of the space defined by the first recess **21K**. In this example, the third recess **211K2** and the fifth recess **211K5** are each located at a region which is the center part of the first structure **2K1** in the *Y*-axis direction, and is the end part of the first structure **2K1** in the *X*-axis direction.

The end of the second recess **211K1** on the positive direction side of the *X* axis is connected to the end face of the third recess **211K2** on the negative direction side of the *X* axis. In other words, the space defined by the second recess **211K1** continuously communicates with the space defined by the third recess **211K2**.

The end of the fourth recess **211K4** on the negative direction side of the *X* axis is connected to the end face of the fifth recess **211K5** on the positive direction side of the *X* axis. In other words, the space defined by the fourth recess **211K4** continuously communicates with the space defined by the fifth recess **211K5**.

Each of the spaces respectively defined by the sixth recess **228K1** and the seventh recess **228K2** is in a pillar shape extending along the *Z* axis. In this example, the bottom of the spaces respectively defined by the sixth recess **228K1** and the seventh recess **228K2** is in a rectangular shape of which the long sides and the short sides extend along the *X* axis and the *Y* axis, respectively. The bottom of each of the spaces respectively defined by the sixth recess **228K1** and the seventh recess **228K2** may be in any shape other than the rectangular shape (e.g., circular, oval, square, polygonal, or other shape).

The long sides of the bottom of each of the spaces respectively defined by the sixth recess **228K1** and the seventh recess **228K2** is slightly shorter than the short sides of the bottom of the space defined by the first recess **21K**. In this example, the sixth recess **228K1** and the seventh recess **228K2** are each located at a region which is the center part of the first structure **2K1** in the *X*-axis direction, and is the end part of the first structure **2K1** in the *Y*-axis direction.

As illustrated in FIGS. **34** and **35**, the first through-hole part **211K3** defines a hole that passes through the wall of the first structure **2K1** defining the end face of the third recess **211K2** on the positive direction side of the *Z* axis in the *Z*-axis direction, and is in a pillar shape extending along the *Z* axis.

In this example, the bottom of the hole defined by the first through-hole part **211K3** is in a rectangular shape. The bottom of the hole defined by the first through-hole part **211K3** may be in any shape other than the rectangular shape (e.g., circular, oval, square, polygonal, or other shape). The hole defined by the first through-hole part **211K3** may be shaped to be a part of a cone.

In this example, the outer edge of the hole defined by the first through-hole part **211K3** on the XY plane is located inside the outer edge of the space defined by the third recess **211K2** on the XY plane.

As illustrated in FIGS. **34** and **36**, the second through-hole part **228K3** defines a hole that passes through the wall of the first structure **2K1** defining the end face of the sixth recess **228K1** on the positive direction side of the Z axis in the Z-axis direction, and is in a pillar shape extending along the Z axis. The third through-hole part **228K4** defines a hole that passes through the wall of the first structure **2K1** defining the end face of the seventh recess **228K2** on the positive direction side of the Z axis in the Z-axis direction, and is in a pillar shape extending along the Z axis.

In this example, the bottom of each of the holes respectively defined by the second through-hole part **228K3** and the third through-hole part **228K4** is in a rectangular shape. The bottom of each of the holes respectively defined by the second through-hole part **228K3** and the third through-hole part **228K4** may be in any shape other than the rectangular shape (e.g., circular, oval, square, polygonal, or other shape). The respective holes defined by the second through-hole part **228K3** and the third through-hole part **228K4** may be shaped to be a part of a cone.

In this example, the outer edge of the hole defined by the second through-hole part **228K3** on the XY plane is located inside the outer edge of the space defined by the sixth recess **228K1** on the XY plane.

Further, in this example, the outer edge of the hole defined by the third through-hole part **228K4** on the XY plane is located inside the outer edge of the space defined by the seventh recess **228K2** on the XY plane.

In this example, the space defined by the end face of the second structure **2K2** on the positive direction side of the Z axis and the first recess **21K** constitutes the first space **SP1** defined inside the main body **2K**.

In this example, the spaces and the holes defined by the end face of the second structure **2K2** on the positive direction side of the Z axis, the second recess **211K1**, the third recess **211K2**, and the first through-hole part **211K3** constitute the channel communicating between the first space **SP1** and the outside of the main body **2K**.

The electronic device **1K** may include a retaining member made from porous material in the first space **SP1**. In this case, the porous material is preferably hydrophilic.

In this example, the first recess **21K**, the second recess **211K1**, the third recess **211K2**, and the first through-hole part **211K3** are coated with hydrophilic films. The hydrophilic films are made from silicon dioxide, for example.

As illustrated in FIGS. **34** and **35**, the first structure **2K1** includes multiple (three in this example) through-hole parts **212K**.

Each through-hole part **212K** defines a hole that passes through the wall of the first structure **2K1** defining the end face of the fifth recess **211K5** on the positive direction side of the Z axis in the Z-axis direction, and is in a pillar shape extending along the Z axis.

In this example, the bottom of the hole defined by each through-hole part **212K** is in a circular shape. The bottom of the hole defined by each through-hole part **212K** may be in

any shape other than the circular shape (e.g., oval, square, rectangular, polygonal, or other shape). The hole defined by each through-hole part **212K** may be shaped to be a part of a cone.

In this example, the area of the bottom of the hole defined by each through-hole part **212K** is smaller than the area of the bottom of the hole defined by the first through-hole part **211K3**. The bottom of the hole defined by each through-hole part **212K** has a diameter between 2 μm and 200 μm , for example.

As illustrated in FIG. **34**, the multiple through-hole parts **212K** are spaced apart at regular intervals along the Y axis.

In the manner as described above, the hole defined by each through-hole part **212K** communicates between the first space **SP1** and the outside of the main body **2K**. The number of the through-hole parts **212K** may be any number other than three.

In this example, each through-hole part **212K** is covered with a water-repellent film. The water-repellent film is made from fluorocarbon resin (e.g., resin containing polytetrafluoroethylene as the main component), for example.

Further, the electronic device **1K** includes a first electrode **213K**, a second electrode **214K**, and multiple (four in this example) volume changing bodies **219K1**, **219K2**, in place of the first electrode **213J**, the second electrode **214J**, and the multiple volume changing bodies **219J** of the ninth embodiment.

The first electrode **213K**, and the second electrode **214K** are configured similarly to the first electrode **213J** and the second electrode **214J**.

The volume changing bodies **219K1**, **219K2** are configured similarly to the volume changing bodies **219J** except for the fact that the volume changing bodies **219K1**, **219K2** are also provided at the fourth recess **211K4**.

The two volume changing bodies **219K1** are provided at the second recess **211K1**, similarly to the volume changing bodies **219J**. The two volume changing bodies **219K2** are further provided at the fourth recess **211K4**.

As a result, in this example, in addition to the channel communicating between the first space **SP1** and the outside of the main body **2K** through the hole defined by the first through-hole part **211K3**, the channel communicating between the first space **SP1** and the outside of the main body **2K** through the hole defined by the through-hole parts **212K**, is also closed responsive to pH. This can increase the possibility of preventing any matter other than the gastric fluid (e.g., fluid with pH different from that of gastric fluid, solid matter, or the like) from entering the first space **SP1**.

In this example, the volume changing bodies **219K1**, **219K2** correspond to a valve that closes the channel communicating between the first space **SP1** and the outside of the main body **2K**, responsive to pH.

Further, the electronic device **1K** includes a first terminal **223K**, a second terminal **224K**, a first conductor **225K**, and a second conductor **226K**, in place of the first through-hole part **221J**, the second through-hole part **222J**, the first terminal **223J**, the second terminal **224J**, the first conductor **225J**, the second conductor **226J**, and the circuit **227J** of the ninth embodiment.

As illustrated in FIGS. **34** and **36**, the first terminal **223K** contacts the end face of the second structure **2K2** on the positive direction side of the Z axis in the space defined by the sixth recess **228K1**. The outer edge of the first terminal **223K** on the XY plane coincides with the outer edge of the second through-hole part **228K3** on the XY plane. The first conductor **225K** connects the first electrode **213K** and the first terminal **223K**.

The second terminal **224K** contacts the end face of the second structure **2K2** on the positive direction side of the Z axis in the space defined by the seventh recess **228K2**. The outer edge of second terminal **224K** on the XY plane coincides with the outer edge of the third through-hole part **228K4** on the XY plane. The second conductor **226K** connects the second electrode **214K** and the second terminal **224K**.

The electronic device **1K** further includes a circuit that is not illustrated, which is connected to the first terminal **223K** through the second through-hole part **228K3**, and is also connected to the second terminal **224K** through the third through-hole part **228K4**.

As set forth above, the electronic device **1K** of the first modification to the ninth embodiment operates similarly to the electronic device **1J** of the ninth embodiment. Accordingly, effects and advantages similar to those of the electronic device **1J** of the ninth embodiment are also achieved by the electronic device **1K** of the first modification to the ninth embodiment.

Further, in accordance with the electronic device **1K** of the first modification to the ninth embodiment, in addition to the channel communicating between the first space **SP1** and the outside of the main body **2K** through the hole defined by the first through-hole part **211K3**, the channel communicating between the first space **SP1** and the outside of the main body **2K** through the hole defined by the through-hole parts **212K**, is also closed responsive to pH. This can increase the possibility of preventing any matter other than the gastric fluid (e.g., fluid with pH different from that of gastric fluid, solid matter, or the like) from entering the first space **SP1**.

According to the above-described technologies, it is possible to prevent a reduction in the power output.

The present invention is not limited to the embodiments described above. Various changes that can be conceived by those skilled in the art may be made to the above-described embodiments, in without departing from the spirit of the present invention, for example. Any combinations of the above-described embodiments and modifications may be adopted as another modification to the above-described embodiments, in without departing from the spirit of the present invention, for example.

All examples and conditional language provided herein are intended for pedagogical purposes to aiding the reader in understanding the invention and the concepts contributed by the inventor to further the art, and are not to be construed as limitations to such specifically recited examples and conditions, nor does the organization of such examples in the specification relate to a showing of the superiority and inferiority of the invention. Although one or more embodiment(s) of the present invention have been described in detail, it should be understood that the various changes, substitutions, and alterations could be made hereto without departing from the spirit and scope of the invention.)

What is claimed is:

1. A battery comprising:
 - a main body having a space therein, and having a channel communicating between an outside of the main body and the space;
 - a pair of electrodes adjoining the space; and
 - a valve that closes the channel in response to a predetermined range of the pH external to the space.

2. The battery according to claim 1, wherein the valve comprises:
 - a valve seat;
 - a support that is dissolved in response to the predetermined range of the pH external to the space; and
 - a valve member that is biased toward the valve seat and supported by the support at a location distant from the valve seat, and closes the channel by contacting the valve seat upon the dissolution of the support.

3. The battery according to claim 1, wherein the valve comprises:
 - a valve seat;
 - a volume changing body that undergoes a volume change in response to the predetermined range of the pH external to the space; and
 - a valve member that is supported by the main body with contacting the volume changing body, and closes the channel by contacting the valve seat upon the volume change of the volume changing body.

4. The battery according to claim 1, wherein the valve is disposed at the channel, and comprises a volume changing body that closes the channel by undergoing a volume increase in response to the predetermined range of the pH external to the space.

5. The battery according to claim 4, wherein at least a part of the main body is made from optically transmissive material such that the volume changing body is irradiated with light through at least the part of the main body.

6. The battery according to claim 1, wherein the valve closes the channel when the pH external to the space is higher than a predetermined threshold.

7. The battery according to claim 1, wherein the valve closes the channel once a fluid has been introduced to the space through the channel, when the pH external to the space is lower than a predetermined threshold.

8. The battery according to claim 1, further comprising a film that coats at least a part of the main body, and is dissolved in response to the predetermined range of the pH external to the space.

9. An electronic device comprising:
 - a battery that generates electric power; and
 - a circuit that is energized by the generated electric power, the battery comprising:
 - a main body having a space therein, and having a channel communicating between an outside of the main body and the space;
 - a pair of electrodes adjoining the space; and
 - a valve that closes the channel in response to a predetermined range of the pH external to the space.

10. The electronic device according to claim 9, wherein the battery is disposed at a first layer, and the circuit is disposed at a second layer adjacent to the first layer.

11. The electronic device according to claim 10, further comprising a second battery different from the battery as a first battery, the second battery being disposed at a third layer that is disposed opposite to the first layer relative to the second layer, the second layer being disposed between the first layer and the third layer.

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